PROTA

Fibres

Plant Resources of Tropical Africa 16

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Fibres

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- Parc Botanique et Zoologique de Tsimbazaza (PBZT), B.P. 4096, Tsimbazaza, Antananarivo 101, Madagascar
- National Herbarium and Botanic Gardens of Malawi (NHBGM), P.O. Box 528, Zomba, Malawi
- Makerere University (MU), Department of Botany, P.O. Box 7062, Kampala, Uganda
- World Agroforestry Centre (ICRAF), P.O. Box 30677, Nairobi, Kenya
- Prosea Association (PROSEA), P.O. Box 332, Bogor 16122, Indonesia

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Plant Resources of Tropical Africa 16

Fibres

Editors: M. Brink
E.G. Achigan-Dako

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Contributors

- S. Acheampong Owusu, Forestry Research Institute of Ghana (FORIG), University P.O. Box 63, KNUST, Kumasi, Ghana (*Eremospatha dransfieldii, Eremospatha macrocarpa*)
- E.G. Achigan-Dako, PROTA Network Office Africa, World Agroforestry Centre (ICRAF), P.O. Box 30677-00100, Nairobi, Kenya (*Abelmoschus ficulneus, Abutilon angulatum, Abutilon grandifolium, Abutilon hirtum, Abutilon longicuspe, Abutilon mauritianum, Abutilon ramosum, Corchorus aestuans, Hibiscus congestiflorus, Hibiscus panduriformis, Hibiscus tiliaceus, Hibiscus vitifolius, Luffa cylindrica, Momordica angustisepala, Piliostigma reticulatum, Urena lobata,* editor)
- W. Adugna, Ethiopian Institute of Agricultural Research, Holetta Research Center, P.O. Box 2003, Addis Ababa, Ethiopia (*Linum usitatissimum*)
- N.S. Alvarez Cruz, Unidad de Medio Ambiente, Delegación del CITMA, Cor. Legon 268 / Henry Reeve y Carlos Roloff, Sancti Spiritus C.P. 60100, Cuba (*Phacelurus gabonensis, Thalia geniculata*)
- P. Baas, Nationaal Herbarium Nederland (NHN), University of Leiden branch, P.O. Box 9514, 2300 RA Leiden, Netherlands (wood anatomy *Bombax buonopozense* & *Ceiba pentandra*)
- A.J. Bagué Serrano, Cmdte. Mariano Hernández 100 altos / Julio A. Mella y Marti, Sancti Spiritus C.P. 60100, Cuba (*Anadelphia afzeliana*)
- E.J. Bertrums, PROTA Network Office Europe, Wageningen University, P.O. Box 341, 6700 AH Wageningen, Netherlands (layout)
- C.H. Bosch, PROTA Network Office Europe, Wageningen University, P.O. Box 341, 6700 AH Wageningen, Netherlands (*Acacia gourmaensis, Acacia kamerunensis, Acalypha filiformis, Campylostemon laurentii, Caperonia fistulosa, Clappertonia ficifolia, Clappertonia polyandra, Cryptolepis oblongifolia, Deinbollia pynaertii, Dicranopteris linearis, Dombeya burgessiae, Entada rheedei, Flagellaria guineensis, Gagnebina commersoniana, Gomphocarpus semilunatus, Helictonema velutinum, Hibiscus diversifolius, Hibiscus micranthus, Hippocratea myriantha, Loeseneriella africana, Loeseneriella apocynoides, Megistostegium nodulosum, Merremia aegyptia, Neoapaloxylon tuberosum, Neuropeltis acuminata, Ormocarpum pubescens, Peddiea africana, Placodiscus splendidus, Polygala butyracea, Salacia mannii, Sansevieria ehrenbergii, Sansevieria liberica, Sida rhombifolia, Soyauxia floribunda, Triumfetta rhomboidea, Typha domingensis, Typha latifolia, Vanilla africana, Viguieranthus glaber*)
- H.P. Bourobou Bourobou, Herbier National du Gabon, IPHAMETRA / CENAREST, B.P. 842, Libreville, Gabon (*Sida cordifolia*)
- M. Brink, PROTA Network Office Europe, Wageningen University, P.O. Box 341, 6700 AH Wageningen, Netherlands (*Afrotrilepis pilosa, Ataenidia conferta, Boehmeria nivea, Bolboschoenus maritimus, Brachystegia floribunda, Brachystegia longifolia, Bulbostylis hispidula, Cola griseiflora, Curculigo seychellensis, Cyperus latifolius, Cyperus ligularis, Dais cotinifolia, Dais glaucescens, Desplatsia subericarpa, Dombeya acerifolia, Dombeya ambongensis, Dombeya*

biumbellata, Dombeya buettneri, Dombeya cacuminum, Dombeya coria, Dombeya elliptica, Dombeya hilsenbergii, Dombeya laurifolia, Dombeya lucida, Dombeya mollis, Dombeya montana, Dombeya pilosa, Dombeya quinqueseta, Dombeya rotunda, Dombeya spectabilis, Dombeya viburnifloropsis, Dypsis lastelliana, Eucalyptus deglupta, Ficus bussei, Ficus capreifolia, Ficus politoria, Ficus tremula, Girardinia bullosa, Girardinia diversifolia, Gnidia daphnifolia, Gnidia glauca, Gnidia lamprantha, Gnidia latifolia, Gnidia subcordata, Gossypium arboreum, Grewia glandulosa, Grewia lasiodiscus, Grewia trichocarpa, Grewia triflora, Halopegia azurea, Haumania danckelmaniana, Haumania liebrechtsiana, Hypselodelphys poggeana, Hypselodelphys violacea, Julbernardia magnistipulata, Kyllinga vaginata, Laportea aestuans, Laportea mooreana, Lepironia articulata, Livistona carinensis, Lodoicea maldivica, Loeseneriella apocynoides, Mapania linderi, Marantochloa congensis, Marantochloa cuspidata, Mezoneuron angolense, Obetia radula, Obetia tenax, Oncocalamus wrightianus, Pandanus abbiwii, Pandanus utilis, Podococcus barteri, Pouzolzia mixta, Pycreus lanceolatus, Raphia hookeri, Raphia palma-pinus, Raphia sudanica, Ravenea lakatra, Sarcophrynium prionogonium, Schoenoplectiella mucronata, Schoenoplectus subulatus, Sclerosperma mannii, Sparrmannia ricinocarpa, Stachyanthus occidentalis, Stachyothyrsus stapfiana, Strychnos boonei, Triumfetta pentandra, Triumfetta pilosa, Triumfetta tomentosa, Urera hypselodendron, Urera rigida, Xerophyta spekei, editor)

- R. Bukenya-Ziraba, Department of Botany, Makerere University, P.O. Box 7062, Kampala, Uganda (*Hibiscus cannabinus*)
- N.S.A. Derkyi, Forestry Research Institute of Ghana (FORIG), University P.O. Box 63, KNUST, Kumasi, Ghana (*Sterculia africana*)
- P. Détienne, CIRAD, Département Persyst, UPR Bois tropicaux, 73 rue Jean-François Breton, TA B-40 / 16 (Bât. 16, Bur. 106), 34398 Montpellier Cedex 5, France (wood anatomy *Julbernardia globiflora*)
- H. de Vries, Biosystematics group, Wageningen University, Gen. Foulkesweg 37, 6703 BL Wageningen, Netherlands (illustrations)
- C.S. Duvall, Department of Geography, Bandelier West, Room 121, University of New Mexico, Albuquerque, NM 87141, United States (*Ceiba pentandra*)
- E. Ebanyenle, Forestry Research Institute of Ghana (FORIG), University P.O. Box 63, KNUST, Kumasi, Ghana (*Eremospatha dransfieldii, Eremospatha macrocarpa, Laccosperma secundiflorum*)
- I.M. El Tahir, PGR Unit / ERC, Agricultural Research Corporation, P.O. Box 126, Wad Medani, Sudan (*Hibiscus sabdariffa*)
- L. Fondio, CNRA / SRCV, 01 B.P. 633, Bouaké 01, Côte d'Ivoire (*Corchorus olitorius*)
- C.Z. Gbéhou, National Herbarium of Benin, Faculty of Technical Sciences, University of Abomey-Calavi, 01 B.P. 4521, Cotonou, Benin (illustrations)
- G.J.H. Grubben, Stationsstraat 75, 6584 AT Molenhoek, Netherlands (*Corchorus olitorius*)
- E.C. Ikitoo, Kenya Agricultural Research Institute (KARI), P.O. Box 57811, 00200 Nairobi, Kenya (*Gossypium hirsutum*)
- L. Jimu, Forestry Unit, Department of Environmental Science, Bindura University of Science Education (BUSE), P.B. 1020, Bindura, Zimbabwe (*Gossypium herbaceum, Julbernardia globiflora, Raphia farinifera*)

- R.B. Jiofack Tafokou, Ecologic Museum of Cameroon, P.O. Box 8038, Yaoundé, Cameroon (*Loeseneriella africana, Marantochloa purpurea, Megaphrynium macrostachyum, Raphia vinifera, Triumfetta cordifolia*)
- S. Kativu, Tropical Resource Ecology Programme (TREP), Department of Biological Sciences, University of Zimbabwe, P.O. Box MP 167, Mount Pleasant, Harare, Zimbabwe (*Hyparrhenia filipendula, Hyparrhenia hirta, Hyperthelia dissoluta*)
- V.A. Kémeuzé, Millennium Ecologic Museum, B.P. 8038, Yaoundé, Cameroon (*Marantochloa leucantha, Pavonia urens, Sarcophrynium brachystachyum, Trachyphrynium braunianum*)
- S. Konsala, Université de Maroua, Institut Supérieur du Sahel, B.P. 46, Maroua, Cameroon (*Combretum aculeatum, Gossypium barbadense*)
- L.K. Kwakye Ameyaw, Forestry Research Institute of Ghana (FORIG), University P.O. Box 63, KNUST, Kumasi, Ghana (*Laccosperma secundiflorum*)
- D. Lemessa, Institute of Biodiversity Conservation, P.O. Box 30726, Addis Ababa, Ethiopia (*Piliostigma thonningii*)
- J.P. Lepetu, Faculty of Agriculture, Botswana College of Agriculture, Private Bag 0027, Gaborone, Botswana (*Imperata cylindrica*)
- D. Louppe, CIRAD, Département Environnements et Sociétés, Cirad es-dir, Campus international de Baillarguet, TA C-DIR / B (Bât. C, Bur. 113), 34398 Montpellier Cedex 5, France (wood anatomy *Julberbardia globiflora*)
- A. Maroyi, Department of Biodiversity, School of Molecular and Life Sciences, University of Limpopo, Private Bag X 1106, Sovenga 0727, South Africa (*Crotalaria juncea, Phragmites australis*)
- S. Masila, P.O. Box 102977-00101, Nairobi, Kenya (*Eucalyptus alba*)
- N.C. McClintock, North Carolina State University, Department of Crop Science, Raleigh, NC 27695-7620, United States (*Hibiscus sabdariffa*)
- P. Mugabi, Department of Forestry, Biodiversity and Tourism College of Agricultural and Environmental Sciences, P.O. Box 7062, Makerere University, Kampala, Uganda (wood anatomy *Bombax buonopozense* & *Ceiba pentandra*)
- L. Mujuru, Bindura University of Science Education (BUSE), Department of Environmental Science, P.B. 1020, Bindura, Zimbabwe (*Diospyros lycioides*)
- S. N'danikou, Plant Sciences Laboratory, Faculty of Agronomic Sciences, University of Abomey Calavi, 04 B.P. 0174, Cotonou, Benin (*Corchorus aestuans, Luffa cylindrica, Piliostigma reticulatum, Urena lobata*)
- R. Niangadouma, Herbier National du Gabon, CENAREST / IPHAMETRA, B.P. 1156, Libreville, Gabon (*Ficus exasperata*)
- B.A. Nkongmeneck, Millennium Ecologic Museum, P.O. Box 8038, Yaoundé, Cameroon (*Pavonia urens, Sarcophrynium brachystachyum*)
- Achmad Satiri Nurhaman, Gang Kosasih No. 59, RT 01 / RW 08, Kel. Cikaret, Kec. Bogor Selatan, Bogor, Indonesia (illustrations)
- N. Nyunaï, Institute of Medical Research and Medicinal Plants Studies (IMPM), P.O Box 3805, Yaoundé, Cameroon (*Acacia gerrardii, Millettia barteri*)
- E. Opuni-Frimpong, Forestry Research Institute of Ghana (FORIG), University P.O. Box 63, KNUST, Kumasi, Ghana (*Eremospatha dransfieldii, Eremospatha macrocarpa, Laccosperma secundiflorum*)

- A.A. Oteng-Amoako, Forestry Research Institute of Ghana (FORIG), University P.O. Box 63, KNUST, Kumasi, Ghana (wood anatomy *Bombax buonopozense* & *Ceiba pentandra*)
- P. Oudhia, SOPAM, 28-A, Geeta Nagar, Raipur, 492001, C.G., India (*Pandanus odoratissimus*)
- F.W. Owusu, Forestry Research Institute of Ghana (FORIG), University P.O. Box 63, KNUST, Kumasi, Ghana (*Broussonetia papyrifera, Sterculia africana*)
- L.P.A. Oyen, PROTA Network Office Europe, Wageningen University, P.O. Box 341, 6700 AH Wageningen, Netherlands (*Adenia firingalarensis, Agave sisalana, Alafia nigrescens, Andropogon pseudapricus, Aristida stipoides, Bombax buonopozense, Bombax costatum, Campylospermum squamosum, Casearia barteri, Cercestis afzelii, Cochlospermum planchonii, Commiphora multijuga, Ctenium elegans, Culcasia seretii, Curiera nigrescens, Cyclosorus interruptus, Diospyros heterotricha, Efulensia montana, Elymandra androphila, Eragrostis pallens, Erica simii, Ficus natalensis, Habropetalum dawei, Hickelia madagascariensis, Juncus rigidus, Kniphofia princeae, Kosteletzkya grantii, Landolphia letestui, Lannea schimperi, Loudetia simplex, Miscanthus junceus, Pachycarpus spurius, Pararistolochia promissa, Paropsia perrieri, Phragmites australis, Phragmites karka, Phragmites mauritianus, Pteleopsis habeensis, Rhytachne rottboellioides, Sesamum triphyllum, Sphagnum cuspidatum, Tiliacora funifera, Tiliacora louisii, Trachypogon spicatus, Triphyophyllum peltatum, Urelytrum giganteum, Urena lobata, Vernonia auriculifera, Wissadula rostrata*)
- K. Segu, AMBERO-GITEC Participatory Forest Management Project, GTZ Sustainable Land Management Programme, P.O. Box 12631, Addis Ababa, Ethiopia (*Phoenix reclinata*)
- T. Soromessa, Addis Ababa University, P.O. Box 1176, Addis Ababa, Ethiopia (*Heteropogon contortus, Hyphaene thebaica*)
- T.C.H. Sunderland, Forests and Livelihoods Programme, Centre for International Forestry Research (CIFOR), P.O. Box 0113 BOBCD, Bogor 16000, Indonesia (*Calamus deërratus, Eremospatha dransfieldii, Eremospatha macrocarpa, Laccosperma secundiflorum*)
- Iskak Syamsudin, Perumnas Bantarjati, Jl. Tatapakan Raya No. 4, Kec. Bogor Utara, Bogor, Indonesia (illustrations)
- R. Takawira-Nyenya, University of Oslo, Faculty of Mathematics and Natural Sciences, Natural History Museum, P.O. Box 1172, Blindern, N-0318 Oslo, Norway (*Sanserieria aethiopica*)
- A.T. Tchinda, Institute of Medical Research and Medicinal Plants Studies (IMPM), Ministry of Scientific Research and Innovation, P.O. Box 6163, Yaoundé, Cameroon (*Cissus quadrangularis*)
- G. Todou, Université de Maroua, Ecole Normale Supérieure, B.P. 55, Maroua, Cameroon (*Combretum aculeatum, Gossypium barbadense*)
- G. Vaughan, Museo Arqueológico de Tunja, UPTC, Avenida Central del Norte, Tunja, Boyacá, Colombia (*Cladium mariscus, Cyperus papyrus, Eucalyptus regnans, Furcraea foetida, Musa textilis*)
- F.G. Vodouhê, Laboratory of Applied Ecology, Faculty of Agronomic Sciences, University of Abomey Calavi, 02 B.P. 8033, Cotonou, Benin (*Piliostigma reticulatum*)

- R.S. Vodouhê, Bioversity International, Sub-office of West and Central Africa, 08 B.P. 0932, Cotonou, Benin (*Luffa cylindrica*)
- E. Wabuyele, National Museums of Kenya, East African Herbarium, P.O. Box 45166-00100, Nairobi, Kenya (*Abroma augusta*)
- W. Wessel-Brand, Paulus Potterhof 23, 4033 AN Lienden, Netherlands (illustrations)
- E.A. Wheeler, Department of Wood and Paper Science, College of Forest Resources, North Carolina State University, P.O. Box 8005, Raleigh, NC 27695-8005, United States (wood anatomy *Julbernardia globiflora*)

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- N. Wulijarni-Soetjipto, Jl. Pahlawan 113, Bogor 16131, Indonesia (coordination illustrators)

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Introduction

Choice of species

PROTA 16: 'Fibres' describes the wild and cultivated plant species of tropical Africa used for their fibres. Some of these are traded on the international market, but many are only used locally, for making tying material and clothes, for thatching, packing and filling, and for the production of baskets, mats, wickerwork, brooms and toothbrushes. Rattans of which the stems are used for tying and wickerwork are also included in this commodity group. Most species have several other, secondary, uses. PROTA assigns one primary use and, if relevant, one or more secondary uses to all plant species used in Africa. For instance, the primary use of *Crotalaria juncea* L. (sunn hemp) is as a fibre plant, and thus it is treated in PROTA 16, but it has several secondary uses, e.g. as a green manure, as a forage and as a medicinal plant. The fibres of *Cocos nucifera* L. (coconut) are also commonly used, but the primary use of this species is as an oil crop, and consequently it is described in PROTA 14: 'Vegetable oils'.

In PROTA 16, some species are treated which, in addition to the primary use as fibre, also have another primary use and consequently are described in two PROTA books. These species are *Ceiba pentandra* (L.) Gaertn. (also in PROTA 7(1): 'Timbers 1'), *Corchorus olitorius* L., *Hibiscus cannabinus* L. and *Hibiscus sabdariffa* L. (also in PROTA 2: 'Vegetables'), and *Linum usitatissimum* L. (also in PROTA 14: 'Vegetable oils').

Comprehensive descriptions are given of 75 important fibres. These major fibre plants comprise mostly wild species, but also several cultivated or partly domesticated species. The accounts are presented in a detailed format and illustrated with a line drawing and a distribution map. In addition, accounts of 173 fibres of minor importance are given. Because information on these species is often scanty, these accounts are in a simplified format and usually do not include a drawing. For another 267 species the information was too scarce to justify an individual treatment and they have only been mentioned in the accounts of related species.

Following the alphabetical treatment of the 'primary use' fibres, all 'secondary use' fibres are listed as 'Fibres with other primary use' and referred to other Handbook volumes.

Plant names

Family: Apart from the classic family name, the family name in accordance with the Angiosperm Phylogeny Group (APG) classification is also given where it differs from the classic name.

Synonyms: Only the most commonly used synonyms and those that may cause confusion are mentioned.

Vernacular names: Only names in official languages of regional importance in Africa are included: English, French, Portuguese and Swahili. It is beyond the scope of PROTA to give an extensive account of the names of a species in all languages spoken in its area of distribution. Checking names would require extensive fieldwork by specialists. Although regional forms of Arabic are spoken in several countries in Africa, the number of African plant species that have a name in written, classical Arabic is limited. Arabic names are therefore omitted. Names of plant products are mentioned under the heading 'Uses'.

Origin and geographic distribution

To avoid long lists of countries in the text, a distribution map is added for the majority of species. The map indicates in which countries a species has been recorded, either wild or planted. It should be realized that for many species these maps are incomplete because they are prepared on the basis of published information, the quantity and quality of which varies greatly from species to species. This is especially the case for wild species which are not or incompletely covered by the regional African floras, and for cultivated species which are only planted on a small scale (e.g. in home gardens). For some countries (e.g. Central African Republic, Chad, Sudan, Angola) there is comparatively little information in the literature. Sometimes they are not covered by recent regional or national floras and although species may be present there, this cannot be demonstrated or confirmed. Even for some major species, there is too little information on distribution and the distribution map has been omitted.

Properties

Information is presented on the morphological, chemical and physical properties of the fibre.

The main morphological properties determining the suitability of fibres for different uses are the length and width of the individual fibre cells ('ultimate fibres'). Cell wall thickness and lumen diameter are generally less important. For the industrial production of fine textiles, a length:width ratio of over 1000 is generally required. Fibres with a length:width well below 1000 can only be used for coarser textiles and cordage. In papermaking the length:width ratio affects the paper's flexibility and resistance to rupture.

The chemical properties mainly concern the amounts of cellulose, hemicelluloses, pectin and lignin in the fibre. Cellulose is the main component of plant fibres, and the higher the cellulose content of a fibre, the greater its value. The term holocellulose refers to the entire carbohydrate fraction of the material, i.e. cellulose plus hemicelluloses, whereas α-cellulose is the fraction isolated by a caustic extraction procedure. It is generally considered to be pure cellulose, but it actually is 96–98% cellulose. The presence of hemicelluloses in material for paper making increases the pulp yield and the strength of the resulting paper, but hemicelluloses are not wanted in dissolving pulps for cellulose-based plastics. Pectin binds fibre cells together. Lignin increases the rigidity of the cell wall, makes it less susceptible to predation and less permeable to water. High-quality fibres contain less than 5% lignin. In paper making, removal or modification of lignin is essential for the production of quality papers.

Important physical properties of plant fibres include strength, elasticity, durability and colour. These characteristics usually vary widely within species, even between fibre strands within the same plant. They also depend on a range of other factors, including temperature, moisture content and test methods. The strength may be given by the tensile strength: the breaking load or force per unit area of cross-section, usually expressed in N/mm². An older method of expression is the breaking length: the length at which the material, when hung up, will break under its own weight. It is usually expressed in km. Another useful characteristic is the elongation at break, which is a measure of the resistance of material to elongation. It is defined as the amount of extension when the fibre breaks, expressed as a percentage of the original length of the fibre. The Young's modulus or modulus of elasticity is the ratio of the stress (force per unit area) or applied load to the strain or deformation produced in a material that is elastically deformed; the higher the value, the stiffer the material.

Description

A morphological characterization of the species is given. The description is in 'telegram' style and uses botanical terms. Providing a description for the general public is difficult as more generally understood terms often lack the accuracy required in a botanical description. A line drawing is added for all major and some lesser-known species to complement and visualize the description.

Management

Descriptions of husbandry methods including weeding, fertilizer application, irrigation, and pest and disease control measures are given under 'Management' and under 'Diseases and pests'. These reflect actual practices or generalized recommendations, opting for a broad overview but without detailed recommendations adapted to the widely varying local conditions encountered by farmers. Recommendations on chemical control of pests and diseases are merely indicative and local regulations should be given precedence. PROTA will participate in the preparation of derived materials for extension and education, for which the texts in this volume provide a basis, but to which specific local information will be added.

Genetic resources

The genetic diversity of many plant species in Africa is being eroded, sometimes at an alarming rate, as a consequence of habitat destruction and overexploitation. The replacement of landraces of cultivated species by modern cultivars marketed by seed companies is another cause of genetic erosion. Reviews are given of possible threats for plant species and of the diversity within species, and reference is made to the IUCN Red list of threatened species where relevant. Information on ex-situ germplasm collections is mostly extracted from publications of Bioversity International (formerly the International Plant Genetic Resources Institute – IPGRI).

References

The main objective of the list of references given is to guide readers to additional information; it is not intended to be complete or exhaustive. Authors and editors have selected two categories of references; 'major references' are limited to 10 references (5 for minor species), the number of 'other references' is limited to 20 (10 for minor species). The references listed include those used in writing the account. Where the internet was used, the website and date are cited.

Alphabetical treatment of fibres

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ABELMOSCHUS FICULNEUS (L.) Wight & Arn.

Protologue Prodr. Fl. Ind. Orient. 1: 53 (1834).

Family Malvaceae

Chromosome number $2n = 72$

Synonyms *Hibiscus ficulneus* L. (1753).

Vernacular names Native rosella (En). Ketmie faux ficus (Fr).

Origin and geographic distribution *Abelmoschus ficulneus* occurs in tropical Africa (including Madagascar), Asia and Australia. In tropical Africa it has a scattered distribution. It occurs mostly in East Africa from Sudan, Eritrea and Somalia southward to Zambia and Mozambique. In West and Central Africa it is reported for Niger, northern Nigeria and Chad.

Uses The stem yields a white fibre used for twine and light cordage. The green stem produces a mucilaginous extract which is an efficient clarifier of sugar-cane syrup. In Egypt the plant is cultivated as a vegetable. The fruits are edible, and in Sudan both the fruits and the leaves are eaten in times of food scarcity. The seeds are used in Arabia to improve the taste of coffee.

Leaves crushed with salted water are used in Indonesia against diarrhoea. In India a decoction of the crushed fresh root is taken to treat calcium deficiency. In case of a scorpion bite, the root is crushed in a glass of water and drunk, while root paste is applied on the area of the sting.

Properties Fibre bundles in transverse section are squarish to radially elongated, widely spaced with cells compactly arranged. Reports on the quality of the fibre of *Abelmoschus ficulneus* from India are contradictory.

Per 100 g dry matter the seed contains 14 g fat and 20–25 g protein. The main fatty acids in the seed oil are: palmitic acid 27–32%, oleic acid 23–32% and linoleic acid 10–42%. The oil also contains malvalic acid and sterculic acid, which are known to cause abnormal physiological reactions in animals. The essential amino acid composition of the seed protein is: lysine 7.1%, methionine 2.8%, phenylalanine 6.8%, threonine 2.8%, valine 5.9%, leucine 6.5% and isoleucine 3.4%. Fruits are rich in vitamin C, with a content of 38 mg per 100 g fresh material.

Botany Annual herb up to 2 m tall; stem thick, glabrous to densely glandular pubescent. Leaves alternate, simple stellate hairy; stipules linear or filiform, 5–12 mm long, hirsute; petiole 2–21 cm long, hairy; blade orbicular, deeply 3–5-lobed, up to 16 cm × 16 cm, cordate at base, lobes subacute to broadly rounded, margin serrate, scabrous on both sides. Flowers bisexual, regular, solitary in leaf axils or in a terminal raceme; pedicel 0.5–2.0(–2.5) cm long, expanded and cup-shaped apically; epicalyx bracts 5–6, linear to lanceolate, up to 12 mm × 2 mm, rough, caducous before expansion of corolla; calyx 17–23 mm long, 5-toothed, tomentellous; petals 5, obovate, 2–3.5 cm × 1.5–3 cm, uniformly white, turning pink; stamens many, filaments united in a column 1–1.5 cm long, glabrous; ovary superior, 5-celled. Fruit an ellipsoid capsule 3–4 cm × 1.5–2 cm, puberulous to pubescent; valves acute to aristate with up to 3 mm long awns. Seeds globose, 3–4 mm in diameter, black, with concentric lines, glabrous or with stellate or long crisped hairs.

Abelmoschus comprises about 6 species in Africa, Asia and Australia. It was previously included within *Hibiscus*. Species delimitation within the genus is based on number, dimensions and persistence of the involucral bracts, indumentum traits, and shape and dimensions of capsules. *Abelmoschus ficulneus* is possibly one of the parental species of the important vegetable *Abelmoschus esculentus* (L.) Moench., the other being *Abelmoschus tuberculatus* Pal & H.B.Singh. *Abelmoschus ficulneus* is sometimes confused with *Abelmoschus esculentus*.

Ecology *Abelmoschus ficulneus* occurs from near sea level up to 1350 m altitude in areas with a pronounced dry season, usually in grassland, bushland, fallows or as a weed in cultivated land. It also occurs in water-logged soils near rivers.

Management *Fusarium chlamydosporum* was found to cause stem canker in most *Abelmoschus* species including *Abelmoschus ficulneus*. The plant is susceptible to yellow vein mosaic virus in Sri Lanka.

Genetic resources and breeding There are no reports of the genetic resources of the species being threatened. However, accessions of *Abelmoschus ficulneus* are available in only a few gene banks. Some collections were reported in Sudan and India. Experiments have indicated that *Abelmoschus ficulneus* does not cross with *Abelmoschus manihot* Medik. and *Abelmoschus esculentus*.

Prospects *Abelmoschus ficulneus* is of mostly local importance in tropical Africa and is likely to remain so. It is probably undercollected in West and Central Africa.

Major references Burkill, 1997; Maiti, 1979; Sinha & Osman, 1982; Sundar Rao, Pantulu & Lakshminarayana, 1983; Verdcourt & Mwachala, 2009.

Other references El Tahir, 1991; Fugro & Jadhav, 2003; Grosvenor et al., 1995; Jagtap, Deokule & Bhosle, 2006; Pal, Singh & Swarup, 1952; Samarajeewa & Rathnayaka, 2004; Schippers, 2000; Siemonsma, 1991; Singh et al., 2007; Vollesen, 1995a.

Authors E.G. Achigan-Dako

ABROMA AUGUSTA (L.) L.f.

Protologue Suppl. pl.: 341 (1782).

Family Sterculiaceae (APG: Malvaceae)

Chromosome number $2n = 16, 20, 22$

Synonyms *Abroma fastuosum* Jacq. (1776, nom. illeg.), *Theobroma augusta* L. (1776), *Abroma fastuosa* R.Br. (1812), *Abroma mollis* DC. (1824).

Vernacular names Devil's cotton, perennial Indian hemp, abroma (En). Abrome, abrome royal (Fr). Abroma (Po).

Origin and geographic distribution *Abroma augusta* is distributed from India throughout South-East Asia to southern China, northern Australia and the Solomon Islands. It is cultivated in India and sometimes in South-East Asia. It has also been grown on a small scale in tropical Africa, especially in DR Congo and Uganda; it has also been introduced into West Africa and Tanzania. The present distribution of *Abroma augusta* in tropical Africa is unclear.

Uses In East Africa the bast fibre has locally been used for making ropes, fishing nets and hammocks. In Asia the fibre is used for a range of purposes, including rope, twine, fishing lines, nets and clothing. Rope made of it is valued for its strength and is used for clotheslines, since it does not stain. Dyed, very fine fibres are used as false hair in Sumatra. In the Philippines *Abroma augusta* is considered a substitute for rattan, and bark splits are made into products such as potholders, baskets and trays. In India and New Guinea the leaves are occasionally eaten. The seed is edible as well. The species has been proposed for reforestation in Asia, as it is able to control cogon grass (*Imperata cylindrica* (L.) Raeusch.). It is sometimes grown as an ornamental.

Abroma augusta is widely used in traditional medicine in India, Bangladesh and other Asian countries, especially for the treatment of menstruation disorders (root, root bark, stem, heartwood, stem bark, leaves, flower, whole plant), gonorrhoea (root, root bark, heartwood, stems, leaves), diabetes (root, bark, leaves, whole plant) and skin problems (root, leaf juice, seed oil, whole plant), and as an antifertility agent (root) and aphrodisiac (root, stem, leaves, whole plant).

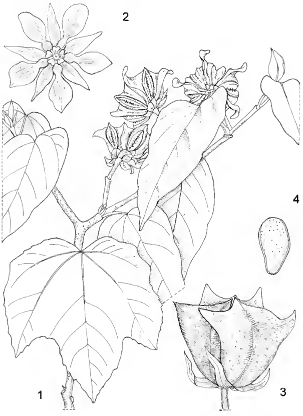
Production and international trade Statistics on production and trade are not available.

Properties The fibre is located in the secondary phloem. The fibre content of fresh, defoliated stems is (3–)4–8(–9)%. The ultimate fibre cells are (1.4–)2–3(–6.4) mm long and (6–)12–20(–39) μm wide, with the lumen diameter being about one third of the total diameter. The ends of the ultimate fibre cells are tapered and sometimes forked. The fibre contains 75–78% cellulose and c. 7% lignin. The extracted fibres, consisting of connected ultimate fibre cells, are 0.5–2.5 m long. Properly prepared fibre is fine, creamy white to golden brown, lustrous, rather silky in appearance, strong and supple. However, the fibre bundles are irregular and coarse and it is difficult to separate the bundles into individual strands. The fibre is difficult to spin, but can be used mixed with jute in the manufacture of hessian. On its own it is considered suitable for making twines and yarn for sackcloth and it can serve as a substitute for jute (*Corchorus* spp.) and hemp (*Cannabis sativa* L.) fibre. In DR Congo the average breaking length of fibre obtained after retting of fresh stems in running water ranged from 26 km to 36 km, with an average of 30.7 km. The breaking length of fibre from Rwanda measured in the 1950s was 31.2 km. An important obstacle to the use of *Abroma augusta* as a source of fibre is that the plants are covered with irritating hairs, making handling very unpleasant and causing dermatitis in sensitive persons.

Aqueous extracts of the root have shown in-vivo hypoglycaemic and hypolipidemic effects in alloxan-diabetic rats, galactotrophic effects in lactating rats, and oxytocic activity. Ethanol extracts of the root showed in-vivo wound healing activity in rats. Petroleum ether, ethanol and chloroform extracts of the root had abortifacient activity. Methanolic extracts of the root bark, stem bark and leaves showed antibacterial activity. Methanolic leaf extracts have shown in-vivo anti-diabetic activity in alloxan-diabetic rats and in-vitro antioxidant activity, but also toxicity in the brine shrimp bioassay. The seed oil has shown phytotoxic activity against *Lemna aequinoctialis* Welve and moderate antifungal activity against *Trichophyton schoenleinii* and *Microsporum canis*; it did not

show antibacterial or insecticidal effects, nor toxicity in the brine shrimp bioassay.
Compounds isolated include the alkaloid abromin, choline, β-sitosterol, stigmasterol and friedelin from the root, β-sitosterol and friedelin from the stem bark, β-sitosterol from the heartwood, and taraxerol, β-sitosterol-acetate and octacosanol from the leaves. The seed yields 20% oil containing palmitic acid (14%), stearic acid (4%), oleic acid (9%) and linoleic acid (72%). The oil does not contain cyclopropenoid acids.

Description Erect shrub or small tree up to 10 m tall, up to 2–4 m tall when cultivated, normally branching at 1–2 m height but due to coppicing often multistemmed from the base; stem and branches with tenacious bark, all parts often with prickly-pointed, irritating, stellate hairs and sometimes also with glandular hairs; orthotropic branches usually remaining vegetative, flowering branches usually plagiotropic. Leaves alternate, simple, highly variable but two main forms exist (heterophylly): lobed (often on orthotropic branches) or unlobed (often on plagiotropic branches); lobed form with petiole up to 40 cm long, blade 3–5-lobed, cordate-ovate in outline, up to 30–40 cm × 30–40 cm, base palmately 3–7-veined, margin irregularly dentate; unlobed form with petiole up to 1.5 cm long, blade lanceolate, 10–23 cm × 9–12 cm, cordate at base, margin denticulate, palmate-pinnately veined. Inflorescence a leaf-opposed or terminal 1(–4)-flowered cyme; peduncle 1–3 cm long; bracts 6–8 mm long. Flowers bisexual, pendent, 3–5 cm in diameter, 5-merous; bracteoles 2, pedicel 1–3.5 cm long, articulate; calyx deeply divided into 5 lobes, lobes entire, triangular, 15–20 mm × 6 mm, greenish; petals 5, spoon-shaped, 2–3.5 cm × 1 cm, base concave and white, blade dark purple, red or yellow, ciliate; staminal tube short, apically with 5 fascicles of anthers alternating with 5 petal-like staminodes, each fascicle with 3(–4) anthers; ovary superior, 2–3 mm long, 5-lobed, 5-celled, style 1–2.5 mm long, with 5 branches. Fruit an obconical capsule 4–5 cm × 3–4 cm, base rounded, top truncate, 5-winged and angled, sometimes beaked, enveloped by the slightly enlarged calyx, densely prickly hairy, apical portion loculicidal, lateral parts septicidally dehiscent, with numerous seeds. Seed cylindrical to obovoid, 3–4 mm × 2 mm, without wings or aril, black. Seedling with epigeal germination



Abroma augusta – 1, habit of fruiting branch; 2, flower seen from above; 3, fruit; 4, seed.
Source: PROSEA

Other botanical information The number of taxa in the *Abroma augusta* complex is disputed. Based on the presence or absence of prickles on the stems and branches, the colour of the flowers and the number of seeds in the capsules up to 3 species have been distinguished: *Abroma augusta*, unarmed, flowers red, capsule with more than 200 seeds; *Abroma mollis* DC., unarmed, flowers yellow, capsule with more than 200 seeds; and *Abroma fastuosa* R.Br., armed, capsules with 50–60 seeds, only occurring in Madagascar. Here the view is accepted that there is only one widespread, highly variable species, but a critical revision is needed.

Anatomy The bast fibres occur in wedge-shaped groups of bundles. The fibre bundles are irregular and coarse, mostly rectangular in transverse section. The number of fibre bundle layers per wedge is 8–11, with c. 21 cells per bundle.

Growth and development *Abroma augusta* is protogynous and allogamous, with pollination by wind and insects. The flowers fall off at the latest one day after opening. It normally spreads by seed, but when the stems are cut, new shoots may emerge from the buds in the axils of the leaf scars at the base of the plant. Suckers may also develop from lateral roots running parallel to the soil surface. In DR

Congo flowering occurs 100–120 days after sowing, and the fruits ripen 60–90 days later.

Ecology *Abroma augusta* can be grown in areas with an average annual temperature above 15°C, and an average annual rainfall of at least 1000 mm. An average annual temperature of 25–30°C and a well-distributed average annual rainfall of 1800–2500 mm are optimal. The species is not suitable for areas with a marked dry season. It is not frost-hardy and it is not found at altitudes above 1200 m. *Abroma augusta* is a short-day plant. The best soils are fertile alluvials with a good structure and good drainage, as it does not tolerate waterlogging for a long period. However, it will also survive and grow when soil conditions are less favourable.

The natural distribution area of *Abroma augusta* is characterized by mean daily temperatures of 27–30 °C in the hottest months, an average annual rainfall of at least 1500 mm and a high relative humidity. Where growing wild, the species grows in tufts or thickets, secondary forest, waste places and village borders and along railways and roads, seemingly preferring forest edges and banks of water courses.

Propagation and planting *Abroma augusta* can be propagated by seed, stem cuttings or suckers emerging from lateral roots. The 1000-seed weight is c. 6 g. For seed propagation fresh material should be used, as seeds show low germination rates and lose viability rather quickly. Soaking in water for 24–48 hours improves germination, and germination of soaked seeds normally starts within 9 days. At a temperature of 33°C germination is more rapid and the final germination percentage higher than at 20–25°C.

Seeds can be sown directly in the field or in nurseries for planting out. In the latter case, the best results in Uganda were obtained by using seedlings c. 30 cm tall, cut back to 15 cm before being planted out. A sowing depth of 7 cm gave better results than less deep sowing. Soil preparation before sowing is desirable, and farm manure or green manure may be incorporated. When plants are planted too wide apart, they branch too much, but with too narrow spacing it is difficult to obtain uniform stands. In spacing trials in DR Congo spacings of 0.4 m × 0.4 m or 1 m × 0.2 m gave the highest fibre yields.

Management In cultivated *Abroma augusta* normally only 2 weedings are necessary, the first at about 20–30 days after sowing, the second about 1 month later.

Diseases and pests In Uganda *Abroma augusta* has proven very susceptible to *Verticillium* wilt, which may kill the plant or lead to stunted growth.

Harvesting The stems are harvested at flowering, when the fibre quality is optimal. However, if only coarse fibre suitable for cordage is to be obtained, harvesting may be done later, resulting in higher yields but a more lignified product. The stems are coppiced at about 25 cm above the ground, as cutting at a lower height may endanger regrowth. Vigorous regrowth normally occurs, with 2–3(–5) new shoots per plant. Up to 4 harvests per year may be possible, but 1–2 harvests is most common. On good soils the plants may be harvested for 3 years, but on poor soils yields decrease sooner.

Yield Fibre yields depend on a number of factors including climate, soil and whether wild or cultivated plants are involved. The average dry fibre yield for the whole economic life of a planted crop has been estimated at 700–1000 kg/ha. *Abroma augusta* can yield 250 kg/ha seed per year.

Handling after harvest The fibre bundles can be extracted by retting the whole stems (fresh or dried) or only the bark (fresh or dried). Where only the bark is retted, it is manually removed in ribbons from the stems immediately after the harvest, when the bark is easiest to remove. Drying of stems or bark may be done in the open field or under shelters. Properly dried bark can be stored for several months. The required retting period depends on prevailing conditions, especially the temperature and nature of the water used (e.g. stagnant or running). Retting of stems normally takes 7–15 days, with older stems needing a longer retting period than young ones. Retting of fresh bark ribbons takes about 11 days, and retting of dry bark ribbons about 13 days. The fresh bark yields about 13% dry fibre on retting, the dry bark about 45%. After retting, the fibre is usually washed, dried and rubbed or beaten to make it supple and to separate the strands. Over-drying makes the fibre brittle.

Genetic resources No germplasm collections of *Abroma augusta* are known to exist.

Breeding Priorities in any future breeding programme should be higher yields and the development of cultivars without irritating hairs.

Prospects *Abroma augusta* yields a strong fibre suitable for cordage and will remain useful for this purpose locally. It has been proposed from time to time as a promising perennial source of bast fibre, avoiding the labour and costs involved in growing annual bast fibre crops. However, the presence of irritating hairs all over the plant and the relatively low yields make an increase in the importance of its fibre, in Asia as well as in Africa, very unlikely.

Major references Aguilar, Jansen & Brink, 2003; Capot et al., 1953; CSIR, 1985; Germain & Bamps, 1963; Greenway, 1950; Kirby, 1948; Kirby, 1963; Lejeune, 1953; National Medicinal Plants Board, 2008; Rahmatullah et al., 2010.

Other references Alam et al., 1996; Basumatary, Ahmed & Deka, 2004; Burkill, 2000; Cheek & Dorr, 2007; d'Oliveira Feijão, 1960; Hussain, Jamil & Rao, 2001; Jacques-Félix, 1935; Khan et al., 2003; Kirtikar & Basu, 1918; Maiti, 1979; Maiti, 1997; Maiti & Chakravarty, 1977; Medina, 1959; Mukherjee & Badruddoja, 1977; Nahar et al., 2009; Nahar et al., 2010; Norman, 1937; Shanbhag et al., 2009; Tandon, Abrol & Kumaria (Editors), 2007; Watt & Breyer-Brandwijk, 1962.

Sources of illustration Aguilar, Jansen & Brink, 2003.

Authors E. Wabuyele

Based on PROSEA 17: Fibre plants.

ABUTILON ANGULATUM (Guill. & Perr.) Mast.

Protologue Fl. trop. Afr. 1: 183 (1868).

Family Malvaceae

Synonyms *Bastardia angulata* Guill. & Perr. (1831), *Abutilon intermedium* Hochst. ex Garcke (1867), *Abutilon eetveldeanum* De Wild. & T.Durand (1899).

Vernacular names Elephant's ear, fluted abutilon (En).

Origin and geographic distribution *Abutilon angulatum* occurs widespread in the drier parts of tropical Africa from Senegal, Gambia and Mali eastward to Eritrea, Ethiopia and Somalia, and southward to Namibia, Botswana, Zimbabwe, Mozambique and South Africa. It also occurs in Madagascar.

Uses The stem bark yields a fibre locally used for string and cordage. In Zambia the fibre is used for stitching mats together. In Madagascar the bark fibre is woven into cloth. The large and soft leaves are sometimes used as toilet paper.

The leaves and flowers are cooked and eaten as a vegetable. The leaves and the inner tissue of the stems are mixed with tobacco and smoked. Leaves are used as fodder. The stems are used as tinder. Bees feed on the flowers. The plant has ornamental value.

In southern African traditional medicine the powdered root is applied on burns. Root extracts are drunk for the treatment of cough and pneumonia, and for easing labour pains. An infusion of the root forms part of preparations taken in case of epilepsy and heartache. Cooked or raw leaves are eaten as a remedy for hiccups. In Madagascar the flowers are made into a lotion applied in case of skin problems.

Properties Fibre from Zimbabwe investigated in the early 20th Century was pale and lustrous, but short, not strong and more brittle than jute, although this may have been due to poor processing. The presence of alkaloids in the plant has been recorded.

Botany Perennial herb or shrub up to 5 m tall; stem and branches angular; all parts greyish hairy, with very short stellate hairs and without long simple hairs. Leaves alternate, simple; stipules subfalcate, c. 4 mm long, reflexed, caducous; petiole 1–12(–24) cm long; blade roundish to broadly ovate, up to 30 cm × 26 cm but usually much smaller, cordate at the base, acute to acuminate at the apex, margin toothed, upper surface dark grey-green, lower surface much paler, 5–9-veined from the base. Inflorescence a large terminal and lateral panicle, loose, much branched, ultimately leafless; peduncle 1–5 cm long, accrescent. Flowers bisexual, regular; pedicel 1–5 cm long; epicalyx absent; calyx cup-shaped, 6–15 mm long, 5-lobed, lobes ovate, acute, submucronate; petals 5, united at the base and adnate to the base of the staminal column, 9–22 mm long, yellow to orange; staminal column 5–8 mm long, filaments 2–5 mm long; ovary superior. Fruit a subglobose schizocarp of follicle-like mericarps, 10–12 mm × 8–9 mm, depressed, umbilicate; mericarps 20–40, 7–9 mm × 5–6 mm, rounded or with an obtuse dorsal angle, 1-seeded. Seeds c. 2.5 mm long, dark brown, smooth to finely papillose, glabrous.

In southern Africa flowering is in December–May. Flowers open in the afternoon.

Abutilon comprises 100–150 species and is distributed in the tropics and subtropics. There is a need for further taxonomical study as the circumscription of several species is obscure.

Abutilon species used as fibre plants in Madagascar include *Abutilon greveanum* (Baill.) Hochr. and *Abutilon pseudocleistogamum* Hochr., both endemic to Madagascar. Their fibres are made into cordage and the sap of their flowers is instilled on wounds to promote cicatrisation. The leaves of *Abutilon pseudocleistogamum* are chewed as a haemostatic. The decoction of the leaves is credited with oxytocic properties.

Within *Abutilon angulatum* two varieties are distinguished:

- var. *angulatum*: indumentum glaucous; flower buds not angular; calyx lobes triangular, usually less than 6 mm long, not or inconspicuously veined; widely distributed in tropical Africa.
- var. *macrophyllum* (Baker f.) Hochr.: indumentum more yellowish or brownish than glaucous; inflorescence usually shorter, narrower and more condensed than in var. *angulatum*; flower buds distinctly angular; calyx lobes ovate to ovate-lanceolate, usually more than 7 mm long, with distinct median veins or more or less keeled; restricted to southern Africa and Madagascar.

Ecology *Abutilon angulatum* occurs from sea level up to 2700 m altitude in open forest, riverine forest, woodland, grassland roadsides and fallow areas. It is a weed in cultivated land.

Management *Abutilon angulatum* is only collected from the wild, but it can be propagated by seed. To obtain fibre, the branches are cut, stripped of leaves and left to soak in water overnight, after which the bark is stripped off and the inner bark separated from the outer bark. After the non-fibrous parts of the inner bark have been scraped off, the fibres are rolled between the palms or on the thigh and allowed to coil to form a rope.

Genetic resources and breeding In view of its wide distribution and occurrence in disturbed habitats, *Abutilon angulatum* is not threatened by genetic erosion.

Prospects *Abutilon angulatum* is a widely available local source of fibre. Too little information is available on the properties of the fibre to assess its potential as a fibre plant.

Major references Burkill, 1997; Hochreutiner, 1955; Kirby, 1963; Ruffo, Birnie & Tengnäs, 2002; Verdcourt & Mwachala, 2009.

Other references Bingham, 1990; Boiteau, Boiteau & Allorge-Boiteau, 1999; Decary, 1946; Hyde & Wursten, 2006; Maite, 1987; Neuwinger, 2000; Raffauf, 1996; SEPASAL, 2009a; Thulin, 1999a; Vollesen, 1995a.

Authors E.G. Achigan-Dako

ABUTILON GRANDIFOLIUM (Willd.) Sweet

Protologue Hort. Brit.: 53 (1826).

Family Malvaceae.

Chromosome number $2n = 42$.

Synonyms *Sida grandifolia* Willd. (1809), *Abutilon tortuosum* Guill. & Perr. (1831).

Vernacular names Hairy abutilon, hairy Indian mallow (En).

Origin and geographic distribution *Abutilon grandifolium* is native to South America. It is cultivated in the tropics and has widely become naturalized. Countries where the species is recorded in tropical Africa include Cape Verde, Senegal, Burkina Faso, Mali, Mozambique and Réunion.

Uses *Abutilon grandifolium* is cultivated in the tropics as a fibre plant and as an ornamental. For instance in Mozambique it has been grown as a potential fibre crop. In Burkina Faso decoctions of leafy or fruiting stems are applied as enema for the treatment of measles, and the leaves and stems are used internally and externally for the treatment of insect bites.

Botany Perennial herb or shrub up to 3 m tall; branches covered with long and slender hairs. Leaves alternate, simple; stipules subulate, caducous; petiole 5–20 cm long; blade ovate, up to 20 cm × 15 cm, base cordate, apex acute or subacuminate, margin toothed, 6–7-nerved, both surfaces stellate hairy. Inflorescence axillary, 1–2-flowered; peduncle 4–5 cm long, up to 12 cm in mature fruit. Flowers bisexual, regular; epicalyx absent; calyx 5-lobed, 1–1.5 cm long, accrescent, with broadly oval segments; petals 5, united at the base and adnate to the base of the staminal column, yellow; stamens many, staminal column very short; ovary superior. Fruit a subglobose schizocarp of follicle-like mericarps; mericarps 8–10, oblong, 12 mm × 7 mm, with an ascendant awn 1.5–2 mm long, hairy, tardily separating, 2–5-seeded.

Abutilon comprises 100–150 species and is distributed in the tropics and subtropics. There is a need for further taxonomical study as the circumscription of several species is obscure.

Ecology *Abutilon grandifolium* occurs at 500–1400 m altitude, along rivers, in wasteland and as a weed in cultivation.

Genetic resources and breeding In view of its wide distribution and occurrence in disturbed habitats, *Abutilon grandifolium* is not threatened by genetic erosion.

Prospects Although *Abutilon grandifolium* has been cultivated in Mozambique as a potential fibre crop, very little information is available on the properties of the fibre as well as on other uses made of the plant in tropical Africa. Therefore it is difficult to assess the potential of this plant.

Major references Afaq-Husain, Saeed & Shahid-Husain, 1988; Burkill, 1997; Marais & Friedmann, 1987.

Other references Brink, Jansen & Bosch, 2003; Brochmann & Rustan, 2002; Fernandez de la Pradilla, 1978; Keay, 1958a; Nacoulma-Ouédraogo, Millogo-Rasolodimby & Guinko, 1998; van Borssum-Waalkes, 1966.

Authors E.G. Achigan-Dako

ABUTILON HIRTUM (Lam.) Sweet

Protologue Hort. Brit.: 53 (1826).

Family Malvaceae

Chromosome number $2n = 42$

Synonyms *Sida hirta* Lam. (1783), *Abutilon graveolens* (Roxb. ex Hornem.) Wight & Arn. (1833).

Vernacular names Florida Keys Indian mallow (En).

Origin and geographic distribution *Abutilon hirtum* is a pantropical species. In tropical Africa it occurs in Cape Verde and from Niger and Nigeria eastward to Eritrea, Ethiopia and Somalia, and southward to Namibia, Botswana, Zimbabwe, Mozambique and South Africa. It also occurs in Réunion and Mauritius.

Uses The stem bark is used for making string, and fibre from the bark is made into cordage and cloth. In Kenya the fruits are eaten raw, while the leaves are browsed by cattle, goats and camels. In the same country the species is said to be used to ease childbirth and to expel the placenta. In traditional veterinary medicine in Uganda a water extract of the bark is used to expel a retained placenta. The plant has ornamental value.

Properties The bark fibre is recorded to be long, fine, soft and strong. The presence of alkaloids in the plant has been recorded.

Botany Perennial herb or shrub up to 2.5 m tall; all or most parts with sticky yellow to orange basally swollen glandular hairs, sparsely tomentose and often with long simple hairs. Leaves alternate, simple; stipules linear to subulate, 3–12 mm long, persistent; petiole 1–20 cm long; blade ovate to suborbicular, 2–24 cm × 1–19.5 cm, cordate at the base, acute to acuminate at the apex, margin toothed, both surfaces hairy, palmately 5–9-veined. Flowers solitary in leaf axils or in narrow panicle with simple or branched peduncle, bisexual, regular; pedicel 1.5–7 cm long, accrescent; epicalyx absent; calyx bell-shaped, 7–18 mm long, 5-fid with oval segments, cuspidate; petals 5, united at the base and adnate to the base of the staminal column, 15–27 mm long, yellow to bright orange, often with dark red to purple base, hairy at the base; stamens many, staminal column 5–9 mm long, filaments 3–5 mm long; ovary superior. Fruit a subglobose schizocarp of follicle-like mericarps, 1–1.5 cm × 1–2.5 cm, truncate, depressed; mericarps 16–30, oblong, 8–12(–14) mm × 5–9(–10) mm, truncate above and terminating in a minute tooth, (1–)3-seeded. Seeds c. 2.5 mm × 2.5 mm, black, reticulate, papillose.

Abutilon comprises 100–150 species and is distributed in the tropics and subtropics. There is a need for further taxonomical study as the circumscription of several species is obscure.

Ecology The plant occurs from sea level up to 1800 m altitude in woodland, bushland, savannas, overgrazed grassland, roadsides, hedges and fences, often near rivers and other moist locations. It is sometimes found on termite nests.

Management *Abutilon hirtum* is a host for okra mosaic virus (OkMV).

Genetic resources and breeding *Abutilon hirtum* is widely distributed in Africa and occurs in a wide range of habitats. Therefore it is not under any threat of genetic erosion.

Prospects *Abutilon hirtum* is of local importance only. Unfortunately, too little information on the fibre properties is available to make a proper assessment of its prospects as a fibre plant.

Major references Beentje, 1994b; Burkill, 1997; Bussmann, 2006; Stave et al., 2007; Verdcourt & Mwachala, 2009.

Other references Balu Perumal, 2001a; Duarte, Gomes & Moreira, 2002; Gradé, Tabuti & van Damme, 2009; Marais & Friedmann, 1987; Mauersberger (Editor), 1954; Munirajappa & Krishnappa, 1993; Raffauf, 1996; SEPASAL, 2009b; Thulin, 1999a; Vollesen, 1995a.

Authors E.G. Achigan-Dako

ABUTILON LONGICUSPE Hochst. ex A.Rich.

Protologue Tent. fl. abyss. 1: 69 (1847).

Family Malvaceae

Vernacular names Mbiha (Sw).

Origin and geographic distribution *Abuti-*

lon longicuspe is distributed from Sudan, Eritrea and Ethiopia through DR Congo and East Africa southward to Angola, Zimbabwe and Mozambique. It also occurs in Egypt and Yemen.

Uses In Kenya the stem is locally used to make string and withies, e.g. for making baskets. In Tanzania it yields string for building houses. In Ethiopia the stem bark is used as rope. The cooked flowers are eaten as a vegetable. The plant is also used as fodder, as ornamental and as a source of bee forage.
In traditional medicine in Kenya the plant is used to ease childbirth and to expel the placenta. The root is used in Tanzania for the treatment of stomach problems.

Properties Fibre from Kenya investigated in the 1950s was yellow, with a tensile strength of 66 kg/mm² and poor spinning quality. The sample had been taken, however, from plants grown under suboptimal conditions, and the growth period and retting time had probably been too short.

Botany Much-branched shrub up to 6 m tall; all parts tomentellous, with or without long simple hairs. Leaves alternate, simple; stipules linear, 6 mm long; petiole 2–19 cm long; blade broadly ovate up to 22 cm × 18 cm, cordate at the base, acuminate to cuspidate at the apex, margin toothed, upper surface dark green, lower surface much paler, both surfaces stellate-velvety, palmately 5–7-veined. Inflorescence a terminal or lateral panicle up to 23 × 13 cm, many-flowered. Flowers bisexual, regular; pedicel 0.5–3(–4) cm long; epicalyx absent; calyx 4–12 mm long, persistent, broadly cup-shaped, 5-lobed, segments acute; petals 5, free, 8–20 mm long, white to pink with purplish centre; stamens many, staminal column cylindrical, 2–7 mm long, purple, filaments 4–12 mm long; ovary superior. Fruit a subglobose schizocarp of follicle-like mericarps, c. 9 mm × 13–15 mm, umbilicate, downy; mericarps c. 20, reniform, 6–10 mm × 4–7 mm, obtuse, 1-seeded. Seeds c. 3 mm × 2 mm, smooth, glabrous.
Abutilon comprises 100–150 species and is distributed in the tropics and subtropics. There is a need for further taxonomical study as the circumscription of several species is obscure.

Ecology *Abutilon longicuspe* occurs at 1000–3000 m altitude in secondary forest and scrub, edges and clearings of upland and riverine forest, grassland, rocky outcrops in grazed areas, and coffee plantations.

Management *Abutilon longicuspe* can be propagated by seed. Seeds have dormancy. In experiments in Molo (Kenya, 2500 m altitude) in the 1950s, yields of 700–1000 kg fibre per ha have been obtained, with dry stems yielding 9% of clean, dry fibre after 13 days of retting.

Genetic resources and breeding *Abutilon longicuspe* is not under any threat of genetic erosion, as it has a wide distribution and is common in disturbed habitats.

Prospects The plant is up to now of local importance only. Too little information is available to capture its prospects as a fibre plant.

Major references Beentje, 1994b; Bussmann, 2006; Jarman & Kirby, 1954; Ruffo, Birnie & Tengnäs, 2002; Verdcourt & Mwachala, 2009.

Other references Exell & Meeuse, 1961; Hauman & Wouters, 1963; Heine & Legère, 1995; Ichikawa, 1987; Kirby, 1963; Mauersberger (Editor), 1954; Medina, 1959; Missouri Botanical Garden, undated; Teketay, 1993; Vollesen, 1995a.

Authors E.G. Achigan-Dako

ABUTILON MAURITIANUM (Jacq.) Medik.

Protologue Malvenfam.: 28 (1787).

Family Malvaceae

Chromosome number $2n = 42$

Synonyms *Sida mauritiana* Jacq. (1781) *Abutilon zanzibaricum* Bojer ex Mast. (1868), *Abutilon longipes* Mattei (1909), *Pavonia patens* (Andrews) Chiov. (1915).

Vernacular names Bush mallow, country mallow (En). Mauve des champs (Fr). Maumanda, mjamanda, mbiha, mopoahabari, mpamba pori (Sw).

Origin and geographic distribution *Abutilon mauritianum* is widely distributed in the drier parts of tropical Africa from Senegal eastward to Eritrea, Ethiopia and Somalia, and southward to Angola, Zambia, Zimbabwe Mozambique and South Africa. The species also occurs in the Comoros and the Seychelles, and is recorded for Mauritius.

Uses The stem bark yields a strong fibre which is locally made into string or rope, used for instance in fishing and for making hammocks. The bark is used for making baskets in Kenya. Pregnant women in Gabon carry around the waist a cord made of the fibre in the belief that it eases delivery. The leaves are used as bandage on open wounds and as toilet paper. Wood from the stem is used for cleaning teeth and the whole twigs are made into brooms. The leaves and flowers are cooked and eaten as a vegetable. The seeds are eaten by nomadic people. The plant is also used as fodder, as an ornamental and as a source of bee forage. In Gabon a mucilaginous extract from the bark is used as mordant in dyeing. Before a contest, wrestlers in Gabon used to put the mucilage from the leaves on themselves.

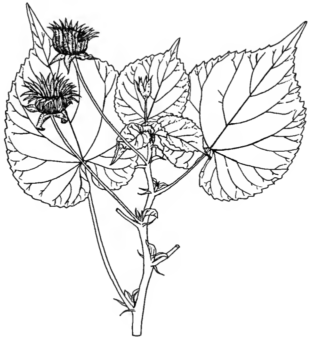
Abutilon mauritianum is widely used in traditional African medicine. In Nigeria an infusion of the root is taken as cooling drink in case of fever. In East Africa the root is chewed as an expectorant, a root decoction is drunk against bronchitis and cramp in the stomach, and a decoction of the root and bark for the treatment of diarrhoea, stomachache, coughs and colds. In Ethiopia the crushed fresh root is boiled and taken orally in case of snake bites. In Nigeria a bark extract is taken as a diuretic. In Benin a decoction of leafy twigs is taken for the treatment of dysentery. In Nigeria leaves are used as rectal suppository to relieve soreness of the rectum in babies and young children. In Tanzania leaves are pounded to a pulp and applied on scabies. An infusion of the macerated leaves together with the powdered root of *Xylopia aethiopica* (Dunal) A.Rich. is drunk in Nigeria for the treatment of venereal diseases such as gonorrhoea. A decoction of the leaves is taken as a gargle for sore throat and as a fomentation to relieve pain in dysentery and haemorrhoids. The leaf sap is drunk in Tanzania against coughs and colds; it is also taken against malaria. In Gabon mucilage from the leaves is used in poultices applied on wounds to facilitate the extraction of foreign bodies such as splinters. A mucilaginous extract from the leaves is used as demulcent. In Uganda the head is washed with a leaf maceration against headache, and the leaves are used against ascariasis. Leaf decoctions are taken against diarrhoea, gonorrhoea, inflammation, bronchitis and catarrh. The powdered fruit is used in preparations used for the treatment of eczema in Tanzania. Seeds are used against cough in Nigeria. In Kenya the species is said to be used to ease childbirth and to expel the placenta. In Benin the fresh plant is ground with kaolin in water, and drunk against dysentery. In DR Congo an infusion of the whole plant is orally or rectally administered for the treatment of asthma and as a tranquilizer.

Properties The leaf is aromatic. Ethanolic extracts of the leaf exhibited antibacterial activity against *Escherichia coli*, *Klebsiella pneumonia* and *Pseudomonas aeruginosa*. Saponins, flavonoids, tannins and alkaloids are reported present in the leaf.

Botany Perennial herb or shrub up to 2.5(–4) m tall; all parts pubescent or tomentose and sometimes also with long simple hairs; stems glandular. Leaves alternate, simple; stipules linear-subulate, 4–9 mm × 0.5 mm; petiole up to 20 cm long; blade ovate to suborbicular, up to 18(–25) cm × 16(–18) cm, cordate at the base, acuminate at the apex, margin toothed; upper surface grey-green, lower surface paler. Flowers solitary in leaf axils or on short axillary shoots, bisexual, regular; pedicel 1.5–8(–12) cm long; epicalyx absent; calyx bell-shaped to cup-shaped, 5-lobed, 6–22 mm long; petals 5, united at the base and adnate to the base of the staminal column, 12–33(–38) mm × 10–15(–25) mm, yellow, orange or reddish; staminal column 5–7 mm long, filaments 3–5 mm long; ovary superior. Fruit a subglobose schizocarp of follicle-like mericarps; mericarps 20–40, 10–17 mm × 4–6.5 mm, with a 3–5 mm long awn, ultimately stellately spreading, black, 2–3 seeded. Seeds c. 2.5 mm long, dark brown, papillose, spiny-papillose towards hilum.

In Benin *Abutilon mauritianum* flowers and fruits year-round.

Abutilon comprises 100–150 species and is distributed in the tropics and subtropics. There is still a need for further taxonomical study as the circumscription of several species is obscure. The type specimen of *Abutilon mauritianum* was collected from Mauritius but the species has never been recollected there.



Abutilon mauritianum – part of stem with fruits. Source: Flore analytique du Bénin

Ecology The species occurs from sea level up to 2200(–2500) m altitude in riverine communities, fallows, along roads, sometimes in savannas, forest margins, woodland, bushland and ruderal sites. It is a weed of rice fields.

Management *Abutilon mauritianum* is only collected from the wild, but it can be propagated by seed. The fibre is separated by retting.

Genetic resources and breeding With its wide distribution and common occurrence in disturbed habitats, *Abutilon mauritianum* is not under any threat of genetic erosion.

Prospects The fibre is credited to be strong, but detailed information on the fibre characteristics is lacking, making it difficult to assess the prospects of *Abutilon mauritianum* as a fibre plant. More detailed information on the types of tannins, saponins and alkaloids present in the leaf would be useful. The antimicrobial activity is worth further investigation.

Major references Banso & Adeyemo, 2004; Burkill, 1997; Bussmann, 2006; Ruffo, Birnie & Tengnäs, 2002; Verdcourt & Mwachala, 2009.

Other references Beentje, 1994b; Chifundera, 2001; Haerdi, 1964; Hamill et al., 2003; Ichikawa, 1987; Kokwaro, 1993; Lejeune, 1953; Neuwinger, 2000; Raponda-Walker & Sillans, 1961; Teklehaymanot, 2009.

Sources of illustration Akoègninou, van der Burg & van der Maesen, 2006.

Authors E.G. Achigan-Dako

ABUTILON RAMOSUM (Cav.) Guill. & Perr.

Protologue Fl. Seneg. tent. 1: 68 (1831).

Family Malvaceae

Origin and geographic distribution *Abutilon ramosum* occurs widespread in the drier parts of tropical Africa from Cape Verde and Senegal eastward to Eritrea, Ethiopia and Somalia, and southward to Namibia, Botswana, Zimbabwe, Mozambique and South Africa. The species occurs also in Yemen, Pakistan and north-western India.

Uses The bark yields fibre. The powdered root is added to beer or porridge to be drunk for the treatment of stomach ailments.

Properties Seeds contain 15.1–26.6% protein and 15.8% oil. Seed oil contains myristic acid (1.0%), palmitic acid (19.1%), palmitoleic acid (0.5%), stearic acid (6.5%), oleic acid (23.7%), linoleic acid (42.6%) and linolenic acid (0.9%). It also contains malvalic acid (2.5%) and sterculic acid (1.3%), which are cyclopropenoid fatty acids known to cause physiological disorders in animals.

Botany Annual or perennial herb or shrub up to 2 m tall; all parts covered with stellate hairs, intermixed with long spreading hairs. Leaves alternate, simple; stipules linear, 1–1.5 mm long; petiole 1–11 cm long; blade broadly ovate to suborbicular, up to 19 cm × 17 cm, sometimes shallowly 3-lobed, cordate at the base, acute to acuminate at the apex, sometimes 3-cuspidate, margin toothed, upper surface dark green, lower surface slightly paler, slightly hairy on both surfaces, palmately 5–7-veined. Inflorescence an axillary 2–6-flowered cyme or some flowers solitary, sometimes merging into a terminal panicle; peduncle slender, 0.5–6 cm long. Flowers bisexual, regular, pedicel up to 2 cm long; epicalyx absent; calyx cup-shaped, 4–12 mm long, 5-lobed, segments acute; petals 5, united at the base and adnate to the base of the staminal column, 4–7 mm × 3 mm, pale yellow to orange; staminal column 1.5–3 mm long, filaments c. 1 mm long; ovary superior. Fruit a subglobose schizocarp of follicle-like mericarps; mericarps 6–10, 6–8 mm × c. 3 mm, terminating in 2–3 mm long awns, pubescent and glandular, tardily separating, 2–3-seeded. Seeds c. 2.5 mm long, reddish to dark brown, papillose.

In Benin *Abutilon ramosum* flowers in November.

Abutilon comprises 100–150 species and is distributed in the tropics and subtropics. There is still a need for further taxonomical study as the circumscription of several species is obscure.

Ecology *Abutilon ramosum* occurs from sea level up to 1800 m altitude in *Acacia* woodland, riverine forest, degraded forest and fallows.

Genetic resources and breeding In view of its wide distribution and occurrence in disturbed habitats, the species is not under any threat of genetic erosion.

Prospects *Abutilon ramosum* is a local source of fibre, but the precise use of the fibre is not documented. Too little information is available on the properties of the fibre as well as on other uses made of the plant to assess its prospects.

Major references Burkill, 1997; Farooqi, 1986; Prakash, 1988; Thulin, 1999a; Verdcourt & Mwachala, 2009.

Other references Akoègninou, van der Burg & van der Maesen, 2006; Brochmann & Rustan, 2002; Exell & Meeuse, 1961; Exell & Roessler, 1969; Hauman & Wouters, 1963; Keay, 1958d; Kokwaro, 1993; Masters, 1868a; Vollesen, 1995a.

Authors E.G. Achigan-Dako

ACACIA GERRARDII Benth.

Protologue Trans. Linn. Soc. London 30(3): 508 (1875).

Family Mimosaceae (Leguminosae - Mimosoideae)

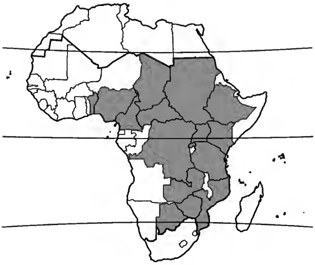
Chromosome number $2n = 52$

Synonyms *Acacia hebecladoides* Harms (1902).

Vernacular names Grey-haired acacia, red-thorn (En).

Origin and geographic distribution *Acacia gerrardii* is distributed from Benin eastwards to Ethiopia and from there southwards to South Africa. A second subspecies is distributed in Israel, Iraq, Jordan and the Arabian Peninsula.

Uses The bark is used for making rope and twine. In Kenya the leaves and pods are eaten by livestock, in Zimbabwe goats browse the leaves. From West Africa, however, it is reported that cattle rarely consume the foliage. *Acacia gerrardii* is considered a useful tree in grazing land as it provides only light shade and does not depress growth of the fodder species beneath. In Uganda trees are spared during land clearance for farming or for rangeland. In Zimbabwe it was found to be suitable to stabilize and reclaim mine waste and ash. In Kenya the thorny branches are used to make fences for livestock enclosures ('bomas'). The wood is used as timber, for carvings, small furniture, poles, posts, tool handles, for charcoal production, and as fuelwood. A soup is made from the bark. Honey bees feed on the flowers. In arid regions of the United States the species is promoted as an ornamental in desert landscape designs.



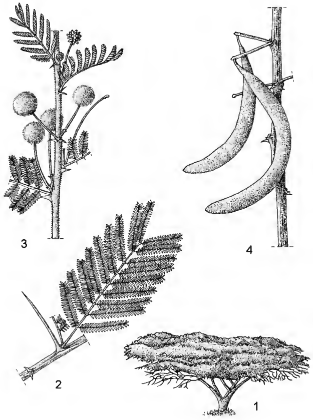
Acacia gerrardii – wild

The inner part of the bark is used either by chewing or in hot water to treat coughs and sore throat. The bark is emetic and used to treat diarrhoea in children. To relieve stomach-pain in Tanzania the root is pounded and taken with hot water, while in Sudan the leaves are used for the same purpose. The pounded and cooked root is mixed with porridge and eaten 3 times per day to cure schistosomiasis. In Sudan the bark and pods are used to kill snails.

Properties The sapwood is creamy brown and is not clearly demarcated from the heartwood, although the latter is tinged pink. The texture is medium to coarse. The wood is fairly hard and moderately heavy, with a density of c. 900 kg/m^3. The wood is prone to splitting and fungal staining and is moderately resistant to borers and termites. It needs careful seasoning. The leaves contain over 17% crude protein. Acetone extracts of the bark have yielded (+)-catechin galloyl esters. Ethyl acetate extracts of *Acacia* species were found to kill snails. The gum is water soluble and contains 43% arabinose, 40% galactose, 1% rhamnose, 9% 4-methyl-glucuronic acid and 7% glucuronic acid.

Description Tree up to 10(–15) m tall, less frequent a shrub; root system deep; trunk 20–30 cm in diameter; bark rough and fissured, grey to blackish brown or black; twigs grey-brown hairy or glabrous; crown flat, umbrella-shaped or irregular, usually narrow and open; branchlets with paired, grey, stipular spines usually up to 1.5 cm long, rarely up to 6 cm long, straight or hooked or recurved. Leaves alternate, bipinnately compound, with (3–)5–10(–12) pairs of pinnae; petiole 0.5–2.5 cm long; rachis (1.5–)2–7 cm long; leaflets usually in 12–28 pairs per pinna, 3–7.5 mm × 1–2 mm, hairy at least on margins near the base. Inflorescence an axillary, globose head, 1–several per leaf axil, with a pair of small bracts in basal half of peduncle; head c. 50-flowered. Flowers 4–6-merous, white or cream, scented; corolla glabrous or only slightly pubescent; stamens numerous, free, anthers glandular, at least some; ovary superior, 1-celled, style long and slender. Fruit a linear-oblong to linear, flattened pod, 4–22 cm × 6–11(–17) mm, curved or rarely straight, valves thin, velvety or glabrous. Seeds almost square in outline, flattened, 9–12 mm × 7 mm, olive-brown. Seedling with epigeal germination.

Other botanical information *Acacia* is a



Acacia gerrardii – 1, tree habit; 2, leaf; 3, part of flowering twig; 4, part of fruiting twig.
Redrawn and adapted by Achmad Satiri Nurhaman

large pantropical genus, comprising more than 1300 species; most of them are found in Australia (more than 900), more than 200 in America, and about 130 in Africa. *Acacia gerrardii* belongs to subgenus *Acacia*, which accommodates all the African *Acacia* species with straight spinescent stipules. *Acacia gerrardii* subsp. *negevensis* Zohary is found in Israel, Iraq, Jordan and the Arabian peninsula. In subspecies *gerrardii* 3 varieties (var. *gerrardii*, var. *latisiliqua* Brenan and var. *calvescens* Brenan) have been distinguished, based on hairiness of young branches, width of the pods and the shape of the spines. However, in Kenya, where all 3 varieties occur, the distinction between them is not felt to be meaningful, because various intermediate forms exist.

Acacia ancistroclada Brenan is a shrub or small tree up to 7.5 m tall, only occurring in southern Kenya and northern Tanzania. In Kenya the bark is used to make string. *Acacia luederitzii* Engl. ('false umbrella thorn') is a tree up to 12 m tall, with a trunk 15–30(–75) cm in diameter, often branching from the base. It is distributed in Zambia, Namibia, Botswana, Zimbabwe, Mozambique, South Africa and Swaziland. Fibres from the inner bark are used for making cordage.

Growth and development Growth rates are moderately high where groundwater is available but slow where this is not the case. Flowering takes place just before or at the start of the rains. The species roots moderately deep and has small lateral roots. It nodulates and fixes nitrogen.

Ecology *Acacia gerrardii* occurs at 450–2200 m altitude on soils ranging from loamy to clayey, most often in wooded savanna, woodland and occasionally in riverine forest. In East Africa it is sometimes common and dominant. In Zimbabwe it is sometimes found on termite mounds, often as a small, gregarious shrub.

Propagation and planting *Acacia gerrardii* is easily propagated by seed. There are 10,000–15,000 seeds per kg. Seeds can be sown in pots or direct at the intended site. Germination is improved by immersing the seed in hot water, allowing it to cool and leaving it to soak for 24 hours. Germination usually takes about 5 days. Seeds can be stored for a long time in a dry place, but they are susceptible to bruchid damage. Ash is added to seeds in storage to reduce infestation and damage.

Management Planting *Acacia gerrardii* close to homesteads is not recommended because of the nasty thorns. Trees can be coppiced at any height of the trunk, but the number of shoots is higher when the stump surface is larger. Where *Acacia gerrardii* needs to be removed, stumps can be dug out or burned, or the cut surface of the stumps can be sprayed with a picloram/2,4-D mixture.

Diseases and pests In Saudi Arabia *Acacia gerrardii* subspecies *negevensis* is classified as susceptible to *Meloidogyne javanica*. Probably the same is true for the African subspecies.

Harvesting The bark of *Acacia gerrardii* is harvested piecemeal and for browse branches are lopped.

Genetic resources There are 2 accessions stored in the USDA National Plant Germplasm System collections. Efforts have been made to explore, assemble and evaluate genetic resources of 6 African *Acacia* species and this has resulted in a collection of 141 provenances. *Acacia gerrardii* was not included but would be a good choice to extend this collection.

Prospects *Acacia gerrardii* is not among the most promising species of *Acacia* but the wide genetic variation within the species and its wide distribution are likely to be a good basis for selection for desirable traits. Analysis of the genetic variation within the Kenyan populations might be worthwhile to understand the level of differentiation between varieties of subspecies *gerrardii*.

Major references Brenan, 1959; Burkill, 1995; Dharani, 2002; Katende, Birnie & Tengnäs, 1995; Timberlake, Fagg & Barnes, 1999.

Other references Arbonnier, 2000; Ayoub, 1985; AZT, 2011; Beentje, 1994b; Bingham, 1990; Brenan, 1970; Grace et al., 2002; Hegnauer & Hegnauer, 1996; Ibrahim & Aref, 2000; Jurasek, Kosik & Phillips, 1993; Mahmoud et al., 1995; Malan & Pienaar, 1987; Maundu et al., 2001; Mucunguzi, 1995; Piha et al., 1995; Ross, 1979; Shackleton, 2000; USDA, ARS & National Genetic Resources Program, 2011; van Wyk & van Wyk, 1997.

Sources of illustration Katende, Birnie & Tengnäs, 1995; Timberlake, Fagg & Barnes, 1999.

Authors N. Nyunaï

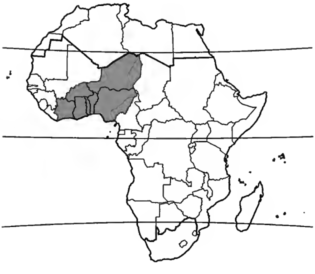
ACACIA GOURMAENSIS A.Chev.

Protologue Bull. Soc. Bot. France, mém. 8: 167 (1912).

Family Mimosaceae (Leguminosae - Mimosoideae)

Origin and geographic distribution *Acacia gourmaensis* is distributed in the southern part of the Sahel from Côte d'Ivoire and Burkina Faso eastwards to Niger and Nigeria.

Uses The bark of the stem and root yields a fibre used for making rope and wickerwork. Young branches, leaves and pods are browsed by goats, sheep and camels. The wood is used for making tool handles. It is also used as fuelwood and for making charcoal. Honey bees feed on the flowers. In Burkina Faso the powdered bark is used for the control of *Striga* spp. An edible gum is obtained from the bark.



Acacia gourmaensis – wild

The roots are chewed in Burkina Faso to overcome convulsive coughing. In Benin the leafy twigs are used in meals and this would help to heal fractures. The bark is a purgative. Unspecified plant parts are used for the treatment of malaria and liver problems.

Properties The wood is hard. The leaves have a crude protein content of 21%.

Botany Shrub or small tree up to 4(–8) m tall; bark thick, corky, with thin corky scales, grey to brown; twigs (nearly) glabrous, yellowish, turning black when bark scales off, lenticellate; crown narrow and open; branchlets with paired, hooked spines, c. 5 mm long. Leaves alternate, bipinnately compound, with 3–4(–5) pairs of pinnae; stipules linear, soon deciduous; petiole 0.5–1.5 cm long with small gland halfway; rachis 1–6 cm long, with or without gland at junction with top pinna pair; leaflets in 1 pair per pinna, 1–17 mm × 2.5–9 mm, asymmetrically ovate, glabrous. Inflorescence an axillary, lax, elongated, spike-like raceme, 1–2 per leaf axil, 3–5 cm long. Flowers 4–6-merous, yellowish-white or cream, scented; corolla glabrous, 2.5–3.5 mm long; stamens numerous, free. Fruit an oblong, flat, papery pod, 2.5–6.5 cm × 1.5–2 cm, dehiscent, glabrous, 1–2-seeded. Seeds round in outline, flattened, 8–10 mm in diameter, brown. Seedling with epigeal germination.

Acacia gourmaensis flowers at the end of the rainy season.

Acacia is a large pantropical genus, comprising more than 1300 species; most of them are found in Australia (more than 900), more than 200 in America, and about 130 in Africa. *Acacia gourmaensis* belongs to subgenus *Acacia*, which accommodates all the African *Acacia* species with straight spinescent stipules. The species shares certain uses and has been confused with *Acacia mellifera* (Vahl) Benth. that has a more eastern and southern distribution.

Ecology *Acacia gourmaensis* occurs in the Guinean and Sudano-Guinean savanna zones with an average annual rainfall of 600–1250 mm, on well-drained heavy and loamy soils and on ironstone and ferruginous soils.

Management The 1000-seed weight is 75–90 g when air-dry. Treatment with hot water increased germination from 30% to 60%. To improve germination seed can also be scarified e.g. by chipping with a knife. Well stored seed should give a germination of c. 90%. Large-scale planting is feasible but trials have shown that growth is slow and therefore other species of *Acacia* are preferred.

Genetic resources and breeding *Acacia gourmaensis* is considered not threatened.

Prospects For the production of fibre and timber there are better choices than *Acacia gourmaensis*. For gum production and for the claimed effect of the stem bark on *Striga* spp., further research may be worthwhile.

Major references Arbonnier, 2004; Burkill, 1995; Ross, 1979; von Maydell, 1983.

Other references Adjanohoun et al., 1989; Chikamai, 1997; Delwaulle, 1979; Geerling, 1982; Guinko, 1997; Kerharo & Bouquet, 1950; Lock, 1989; Traoré et al., 1998; Zaré, 1991.

Authors C.H. Bosch

ACACIA KAMERUNENSIS Gand.

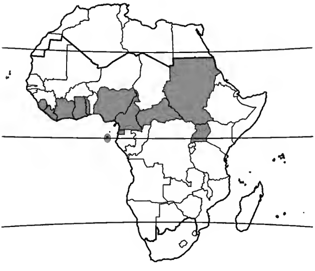
Protologue Bull. Soc. Bot. France 60: 459 (1913).

Family Mimosaceae (Leguminosae - Mimosoideae)

Synonyms *Acacia pennata* sensu auct. p.p.

Origin and geographic distribution *Acacia kamerunensis* is distributed from Sierra Leone eastwards to Sudan and Uganda.

Uses The stem yields a strong fibre widely used for cordage and fishing gear. In Ghana the fibre is made into mats for drying cocoa beans. Children use it for making whips for spinning tops. The lianas are used for tying, often 2 or more twisted to increase strength. The interior part of the stem is used as a toothbrush and the roots serve as chew-sticks. In southern Ghana the roots are among the 3 most traded and popular chew-sticks. The fibres are relatively soft and the use of *Acacia kamerunensis* roots as chew-sticks is especially popular with children and the elderly. The pods contain tannin and are used in Ghana for tanning leather. The leaves are browsed by livestock.

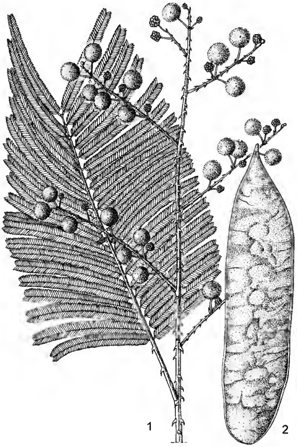


Acacia kamerunensis – wild

In traditional medicine in Ghana the dried leaves are ground, boiled in water and drunk as a cure for measles. The pulverized dried leaves are used for dressing wounds. The root bark or the whole root is pulverized and dissolved in palm-wine and a woollen plug is soaked in the liquid and inserted in a carious tooth to ease the pain. Leaf sap is applied as a liniment to treat skin diseases and affections including parasites. A decoction of the leaves is used as a bath or is drunk to bring down fever. The root boiled with flour serves as an aphrodisiac. In Nigeria it is recommended to a tense, nervous person to boil the leaves and drink the liquid every morning. In Cameroon the leaves are used to cure gastric ulcers and to relieve pain in the hip. In Ghana the leafy twigs are used as a fish-poison, and in Côte d'Ivoire the leaves are used for this purpose.

Properties The butanolic fraction of leaf extracts has shown in-vivo analgesic and anti-inflammatory activity in mice and rats, which may be due to the presence of various flavonoids (isovitexin and pyranosides of quercetin, apigenin and isorhamnetin).

Description Liana or scandent shrub to over 5 m tall; bark rough, with longitudinal bands with downward curved prickles, grey, younger stems yellow-brown, soft short hairy to almost glabrous. Leaves alternate, bipinnately compound, with 10–30 pairs of pinnae; stipules not spinescent, up to 5 mm × 1 mm, soon falling; petiole 1.5–3.5 cm long, with gland near the base; rachis 3–13 cm long, with glands at the base of top few pairs only; leaflets in 28–80 pairs per pinna, linear, c. 7 mm × 2 mm, midrib excentric at base, apex obtuse or subacute, glabrous or almost so. Inflorescence a globose head 4–8 mm in diameter, arranged in panicles, peduncle 3–15 mm long, with a pair of small bracts at the base. Flowers bisexual, 4–6-merous, yellowish-white; calyx up to 2.5 mm long, without glands, glabrous or shortly pubescent; corolla 2–3 mm long, lobes c. 0.5 mm long; stamens numerous, free, up to 5 mm long; ovary superior, style c. 4 mm long. Fruit an oblong, flattened, leathery pod, 8–14 cm × 1.5–



Acacia kamerunensis – 1, part of flowering twig; 2, fruit.
Redrawn and adapted by Achmad Satiri Nurhaman

3 cm, straight, margins entire, 1–1.5 mm thick, brown or pale brown, dehiscent. Seeds elliptical in outline, flattened, 4.5 mm × 1.5–2.5 mm, dark brown.

Other botanical information *Acacia* is a large pantropical genus, comprising more than 1300 species; most of them are found in Australia (more than 900), more than 200 in America, and about 130 in Africa. *Acacia kamerunensis* is one of c. 13 species belonging to the so-called *Acacia pennata* complex. These species have primitive features like a scrambling or climbing habit and they lack nodulation. Unlike other members of the subgenus *Aculeiferum*, inflorescences in this group are globose rather than spicate. The name *Acacia pennata* (L.) Willd. has been used for all 13 African scrambling and climbing members of the genus whereas the name is considered to apply only to a species restricted to South-East Asia. Especially in the ethnobotanical literature of tropical Africa it is often impossible to link uses of '*Acacia pennata*' to the correct species name.

Growth and development The combination of circumnutation and thorns enables *Acacia kamerunensis* to climb in and attach to trees.

Ecology *Acacia kamerunensis* is a species of lowland rain-forest and secondary forest. In Uganda it occurs up to 1450 m altitude.

Propagation and planting The 1000-seed weight is c. 58 g, but no information has been published on multiplication of *Acacia kamerunensis*.

Management In forest regeneration *Acacia kamerunensis* reduces the establishment and growth of valuable timber tree species such as *Khaya anthotheca* Heckel and *Nauclea diderrichii* (De Wild. & T.Durand) Merr. Measures should therefore be taken to control the liana and promote growth of the trees.

Genetic resources The most popular and widely traded chew-sticks in West Africa are obtained from *Garcinia afzelii* Engl. and other species of the genus. The huge demand for *Garcinia afzelii* chew-sticks endangers supply and results in price increases. This situation also results in an increased demand for *Acacia kamerunensis* chew-sticks, and wild populations of *Acacia kamerunensis* may eventually be threatened.

Prospects Developing protocols for the sustainable harvest of *Acacia kamerunensis* would ensure that it can continue to be traded profitably as chew-sticks. Phytochemistry of material of well-identified species of the *Acacia pennata* group could give a sound understanding of medicinal uses.

Major references Abbiw, 1990; Brenan & Exell, 1957; Burkill, 1995; Hawthorne & Jongkind, 2006; Nacro & Millogo-Rasolodimbi, 1993; Ross, 1979; Timberlake, Fagg & Barnes, 1999.

Other references Addo-Fordjour et al., 2008; Adjanohoun et al., 1989; AduTutu et al., 1979; Arbonnier, 2000; Blay, 2004; Bongers, Parren & Traoré (Editors), 2005; Brenan, 1959; Chifundera, 2001; Dongmo et al., 2007; Dongmo, Nguelefack & Lacaille-Dubois, 2005; Geerling, 1982; Neuwinger, 1998; Toledo-Aceves & Swaine, 2008a; Toledo-Aceves & Swaine, 2008b; Velayos et al., 2010; Verger, 1995; von Maydell, 1983; Watt & Breyer-Brandwijk, 1962; Zapfack et al., 2001.

Sources of illustration Ross, 1979.

Authors C.H. Bosch

ACALYPHA FILIFORMIS Poir.

Protologue Encycl. 6: 205 (1804).

Family Euphorbiaceae

Synonyms *Acalypha reticulata* (Poir.) Müll.Arg (1865).

Vernacular names Queue de rat (Fr).

Origin and geographic distribution *Acalypha filiformis* is distributed on most Indian Ocean Islands but is absent from the Seychelles. A single specimen has been collected in Saint Helena but the species has not been reported from this island since.

Uses The flexible stems and branches of *Acalypha filiformis* are used in Madagascar to make baskets and fish traps. The stems are also suitable to make walking sticks. The leaves are used as tissues and are especially useful to clean children. A decoction of the whole plant is taken 3 times per day to treat dysentery.

Properties Preliminary phytochemical screening revealed the presence of tannins and anthocyanins in the root bark, stem bark and leaves, and alkaloids and saponins in the leaves.

Botany Monoecious shrub or liana up to 6 m tall; young stems pubescent. Leaves arranged spirally, simple; stipules slender, 1–8 mm long, pointed, soon falling; petiole (1–)5–15(–33) mm long; blade ovate to elliptical-ovate, seldom elliptical, (1.5–)2–9(–11) cm × 1–4(–5) cm, base cuneate or obtuse and 3(–5)-veined, apex acute to rounded, margin serrate, pubescent while young, lateral veins 4–6 pairs. Inflorescence spicate or subracemose, axillary, solitary, up to 16 cm long, bracteate, with a terminal male portion and 1–2 female units below the male portion. Flowers unisexual, sessile, without petals; male flowers with calyx 4-partite, stamens 8; female flowers usually 2, on peduncle up to 3 cm long, enclosed by large bract, 3–10 mm in diameter, sepals 3, triangular-ovate, ovary superior, 3-celled, globose to 3-lobed, styles 3, free. Fruit a 3-lobed capsule c. 2.5 mm long, glabrous or with few spines, 3-seeded. Seeds subglobose, glabrous, grey-brown.

Acalypha is a large genus comprising about 460 species, occurring mainly in the tropics but extending to warm temperate areas. Tropical Africa and Asia have about 65 and 25 species, respectively, tropical America almost 400. *Acalypha filiformis* is a variable species. The flexible stems of *Acalypha emirnensis* Baill. and *Acalypha leptomyura* Baill. are also used in Madagascar to make baskets and fish traps.

Ecology In Réunion and Mauritius *Acalypha filiformis* occurs at low altitudes and survives in degraded habitats. In Madagascar the species is recorded as occurring in forest and ruderal sites, from sea-level up to 2000 m altitude.

Genetic resources and breeding As *Acalypha filiformis* has a fairly wide distribution and has adapted to ruderal conditions, it is unlikely that it is or will become threatened in the near future.

Prospects *Acalypha filiformis* will remain important at local level for its flexible stems. It is only occasionally used as a medicinal plant and is likely to remain of local importance, unless new pharmacological research reveals interesting activities.

Major references Boiteau, Boiteau & Allorge-Boiteau, 1999; Coode, 1982; Govaerts, Frodin & Radcliffe-Smith, 2000; Rabemanantsoa, Roger & Jeannoda, 2007; Tida, 1997.

Other references Debray, Jacquemin & Razafindrambao, 1971; Missouri Botanical Garden, undated.

Authors C.H. Bosch

ADENIA FIRINGALAVENSIS (Drake ex Jum.) Harms

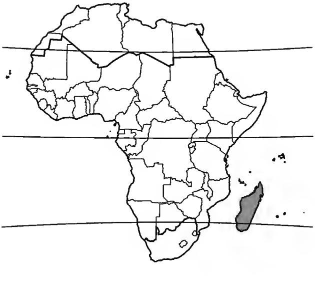
Protologue Engl. & Prantl, Nat. Pflanzenfam. (ed. 2) 21: 490 (1925).

Family Passifloraceae

Synonyms *Ophiocaulon firingalavense* Drake ex Jum. (1903).

Vernacular names Bottle liana (En).

Origin and geographic distribution *Adenia firingalavensis* is endemic to western and southern Madagascar.



Adenia firingalavensis – wild

Uses A poor-quality fibre is extracted from the trunk. The wax covering the trunk is occasionally collected. The plant is very toxic and is only used medicinally by very experienced traditional healers. In spite of its large size and slow growth, it is grown by specialist collectors of succulents.

Production and international trade *Adenia firingalavensis* is traded internationally as an ornamental, but on a small scale only.

Properties All parts of *Adenia firingalavensis* are toxic. It contains the cyanohydrin glycosides volkenin and tetraphyllin B.

Botany Large, deciduous, succulent liana up to 15 m long; bole conical to subspherical, up to 2 m tall and 50 cm in diameter; outer bark blue-green, warty and mostly covered with a thick greenish layer of wax; branches vine-like, up to 3.5 m long and 1.5–3 mm thick. Leaves short-lived, simple; axils bearing a tendril or an inflorescence; stipules triangular to filiform, up to 1 mm long; petiole 2–10(–12) cm long, with 2 glands at apex; blade orbicular to ovate, entire to 3(–5)-lobed, 3–10(–17) cm × 2.5–10(–18) cm, base cordate, apex acuminate, margin entire, brownish green above, pale green-glaucous beneath, venal reticulation distinct. Tendrils simple, 4–10 cm long. Inflorescence axillary on short shoots or peduncled, bearing 1–5 male flowers or 1(–2) female flowers. Male flowers funnel-shaped, up to c. 3 cm long; sepals 5, linear, 9–30 mm × 1–2 mm; petals 5, lanceolate-linear, 6–16 mm × 1–2 mm; stamens 5, filaments 4–9 mm long, base connate, anthers c. 5 mm × 0.3 mm; corona inconspicuous or absent; rudimentary ovary present. Female flowers broadly funnel-shaped, up to c. 40 mm × 5 mm; sepals narrowly lanceolate to linear, up to 30 mm × 2 mm; petals lanceolate to linear, up to 20 mm × 2.5 mm; staminodes 5, linear; corona inconspicuous or absent; ovary ovoid-oblong, 4–8 mm long, 6-ribbed, styles 3, stigmas somewhat kidney-shaped. Fruit an ovoid capsule 6–7 cm × 3–4 cm, 1-celled; pericarp leathery, opening with 3 valves, 30–60-seeded. Seed ovoid to globose, 6–8 mm × 5–7 mm, flattened. Seedling with epigeal germination.

Adenia firingalavensis is slow-growing. It is generally common, although with locally poor regeneration rates. Its flowers and fruits from August to December. The axillary tendrils are modified inflorescences.

Adenia comprises c. 100 species with centres of diversity in West and East Africa, Madagascar and South-East Asia. In mainland tropical Africa about 60 species occur, in Madagascar about 30 which are all endemic.

Adenia stylosa (Perr.) D.J.Hearn (synonym: *Adenia firingalavensis* var. *stylosa* (H.Perrier) W.J.de Wilde) from northern Madagascar resembles *Adenia firingalavensis*, but molecular and morphological data suggest it is a separate species.

Adenia olaboensis Claverie, a large liana with swollen trunk, endemic to western Madagascar, yields a flexible fibre of mediocre quality. It occurs underneath shrubs and in secondary forest. The stem is rather horizontal and grows to 4 m, with a diameter of 40 cm, and has characteristic vertical ribs. The vines grow to a diameter of 12 cm and form meters-long secondary trunks and lianas. The larger vines have the same rib-pattern as the trunk. Leaves are simple, heart-shaped, 7 cm × 6 cm, thick, green above, and pale greenish below. The flowers are yellow. According to Sakalava folklore, the plant should be planted on the eastern side of a house.

Adenia cladosepala (Baker) Harms (synonym: *Adenia ambongensis* Claverie), a robust liana lacking a thickened trunk and occurring in north-western Madagascar, yields a fibre of rather poor quality.

Ecology *Adenia firingalavensis* grows from sea level up to 500 m altitude in sheltered places in shade of dry forest, scrub and rocky areas derived from limestone.

Management Propagation is possible by seed or cuttings.

Genetic resources and breeding Although *Adenia firingalavensis* is slow-growing, with locally poor regeneration rates, it is locally common and occurs in a number of protected areas. It is in some demand internationally as a horticultural plant, but the number of plants exported from Madagascar is small, about 550 plants from 2000 to 2006. The export is controlled under CITES 2. *Adenia olaboensis* is also included in Annex 2 of CITES.

Prospects *Adenia firingalavensis* is likely to remain of marginal economic importance.

Major references de Wilde, 1971; Hearn, 2006; Hearn, 2007; Perrier de la Bâthie, 1945.

Other references Bernhard, 1999; Decary, 1946; de Wilde, 1970; Medina, 1959; Olafsdottir, Andersen & Jaroszewski, 1989; Rietveld & Farazanamalala, 2008.

Authors L.P.A. Oyen

AFROTRILEPIS PILOSA (Boeck.) J.Raynal

Protologue Adansonia, sér. 2, 3: 258 (1963).

Family Cyperaceae

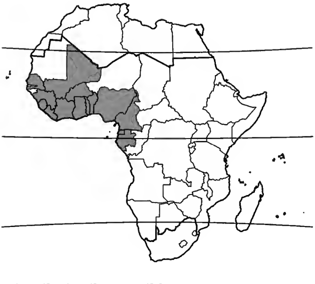
Synonyms *Trilepis pilosa* Boeck. (1875), *Eriospora pilosa* (Boeck.) Benth. (1881), *Catagyna pilosa* (Boeck.) Hutch. (1936).

Vernacular names Devil grass (En).

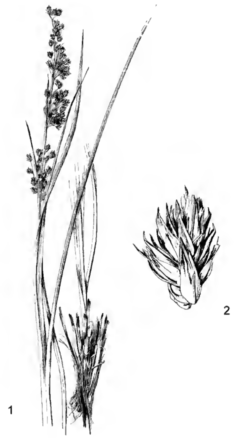
Origin and geographic distribution *Afrotrilepis pilosa* is distributed from Senegal to Gabon.

Uses The leaves are used for thatching huts in Guinea and northern Sierra Leone.

Botany Perennial, robust, tufted herb up to 80 cm tall, with often erect or ascending, trunk-like rhizome, forming mats; stem up to 60 cm long, 2–4 mm in diameter, triangular in cross section. Leaves arranged spirally, inserted in the lower part of the stem; sheath closed over its whole length, with a small triangular tongue opposite the blade, the tongue with an obtuse apex and ciliate margin; blade linear, 10–40 cm × 3–10 mm, apex acuminate, margin ciliate. Inflorescence a terminal, lax panicle 15–30 cm × 3–10 cm, with tiers of whorls, the lower one subtended by a short leafy bract, each whorl with 4–10 partial inflorescences; partial inflorescences dense, obconical to almost globular, c. 5 mm × 4.5 mm, usually pale or reddish brown, consisting of several male spikelets topped with several bisexual ones. Spikelets 2-flowered, with 2 male flowers or with 1 lower female flower and 1 upper male flower, seldom with 2 female flowers, glumes ovate, 3–3.5 mm long, apex acuminate and mucronate, reddish brown; flowers unisexual, 1–2 mm long, female flowers with superior ovary and 3 stigmas. Fruit a nutlet c. 3.5 mm long, 3-angled, red-brown, with numerous white bristles c. 2 mm long, 1-seeded.



Afrotrilepis pilosa – wild



Afrotrilepis pilosa – 1, habit; 2, inflorescence. Source: Flore analytique du Bénin

Afrotrilepis pilosa is a poikilohydric plant, which means that it desiccates and remains dormant when its environment dries out, but rehydrates when water becomes available again.

Afrotrilepis comprises only 2 species, distributed in north-western Africa.

Ecology *Afrotrilepis pilosa* occurs on granite and gneiss outcrops (inselbergs). It can grow into a kind of mat covering bare rocks and locations cleared by erosion, felling or fire, leaving only little space for other species to become established. These almost monospecific mats may become several-hundreds year old. *Afrotrilepis pilosa* mats covering granite outcrops in Sierra Leone are recorded to be up to 2.5 m thick. The plant is resistant to bush fires.

Genetic resources and breeding *Afrotrilepis pilosa* is fairly widely distributed, but occurring in specific habitats. There are no records of it being threatened with genetic erosion.

Prospects *Afrotrilepis pilosa* is only recorded to be used locally for thatching, and its importance is unlikely to increase.

Major references Burkill, 1985; Haines & Lye, 1983; Parmentier, 2003; Porembski, Brown & Barthlott, 1996; Simpson & Inglis, 2001.

Other references Akoègninou, van der Burg & van der Maesen, 2006; Burkill, 2000; Clarke, 1901–1902; Hambler, 1961; Hooper & Napper, 1972; Nelmes & Baldwin, 1952; Scholz & Scholz, 1983.

Sources of illustration Akoègninou, van der Burg & van der Maesen, 2006.

Authors M. Brink

AGAVE SISALANA Perrine

Protologue Tropical Plants - US House of Representatives Rep. no. 564: 87 (8–9, 16, 47, 60, 86) (1838).

Family Agavaceae (APG: Asparagaceae)

Chromosome number $2n = 150$ (pentaploid)

Synonyms *Agave rigida* Mill. var. *sisalana* Engelm. (1875).

Vernacular names Sisal, sisal hemp, sisal agave, hemp plant (En). Sisal, langue de bœuf, pite sisal (Fr). Sisal, agave, linho sisal (Po). Mkatani, mkatani mkonge (Sw).

Origin and geographic distribution *Agave sisalana* is probably of southern Mexican origin, but wild forms are not known. It has been widely introduced in the tropics and subtropics, in India between 1885 and 1892, in Tanzania in 1893, in Brazil at the end of 19th Century, and in Kenya between 1903 and 1908. *Agave sisalana* is now present in many tropical and subtropical countries. Until the 1960s Tanzania was the leading producer of sisal, but since then Brazil has become by far the most important producer, followed by Tanzania, Kenya, Madagascar and China. Other countries in Africa that commercially produce sisal include Guinea, the Central African Republic, Ethiopia, Malawi, Mozambique, Angola, South Africa and Morocco. Sisal has also been grown in Uganda, Zimbabwe and Mauritius, but its exact distribution in tropical Africa is unclear

Uses The main sisal product is the long fibre ('line fibre') from the leaves, which constitute the major part of the 'hard fibres' of commerce. This fibre is mainly used to make twine, rope, string, fishing nets, buffing cloth, dart boards and hammocks. It has been widely used to make binder and baler twines, but this use has declined steadily over the past decades due to the increasing application of synthetic twines. Sisal fibre is also woven into material for carpet-backing, sacks, industrial fabrics and matting and is used as padding in cars and upholstery. Shorter fibres ('tow') are used for the production of upholstery material, mats, carpets, building panels and cellulose. In rural areas in tropical Africa sisal fibre is used for making rope, string, mats and sandals. In parts of southern Africa it seems to have replaced *Sansevieria* spp. as the main source of fibre for these purposes.

Sisal fibre is used for making specialty papers, such as cigarette paper, newsprint, bag paper, carbon paper, safety and banknote paper, filter paper and tea bags. However, sisal pulp is more often used in the production of common grade paper, in blends with wood pulp to add porosity or to reinforce weaker pulps, such as those from recycled paper. In recent years possibilities for the use of pulped sisal fibre as reinforcement in composite board manufacturing has been investigated. Whole leaves and sisal waste material may also be used as a source of pulp for papermaking.

The long and straight inflorescence stalks are used for house construction, fencing and thatching. Waste material after fibre extraction and boles remaining at the end of the life cycle of a crop may serve as animal feed, either directly or after ensilage. A very hard wax is obtained from the leaf-cuticle and pectin can be obtained from sisal leaves. The pulp from the leaves after fibre extraction may be returned to the field as manure. Waste material is sometimes fermented to produce an alcoholic beverage or for biofuel production. Sisal is planted as a fence plant, to mark field boundaries, and to stabilize soil. Several edible mushrooms, notably *Coprinus cinereus*, grow in large quantities on the waste heaps of sisal factories in Tanzania and provide a year-round source of food.

Hecogenin from sisal leaves has been used as a precursor in the partial synthesis of corticosteroids such as cortisone, hydrocortisone and prednisone. In traditional medicine in East Africa a root decoction is drunk as a diaphoretic and a leaf decoction as a diuretic, while sap from the leaves is taken to treat constipation and stomach-ache and externally applied to cuts. In Morocco sap from the leaves is used as a wash for skin diseases. It is also used against syphilis, pulmonary tuberculosis, and jaundice. It can be used as a laxative. In India the plant is considered emmenagogue and abortive.

Production and international trade In terms of production, sisal occupies 6th place among fibre plants, representing 2% of the world's production of plant fibres, and it accounts for about 70% of the world's hard fibres. World sisal production reached its peak of over 600,000 t per year in the 1960s, but has declined gradually since then due to the introduction of synthetic fibres and stagnating prices. The annual sisal production in Tanzania peaked in 1964 at about 230,000 t from about 230,000 ha, whereas in Brazil a peak of about 300,000 t was reached in the 1970s. While Brazil has nearly regained the level of its peak production, production has dwindled in most other countries. Tanzania has become the second largest producer, but at a production of about 10% of its peak. Kenya now holds 3rd place, while Madagascar, which has kept its annual production much more stable at about 15,000 t, takes place 4, before China. According to FAO estimates the average annual world sisal fibre production (line fibre and tow) in 2004–2008 was about 350,000 t, the major producers being Brazil (230,000 t), Tanzania (29,000 t), Kenya (25,000 t), Madagascar (18,000 t) and China (17,000 t).

The international trade in sisal has fluctuated strongly over time. Total world exports averaged about 90,000 t per year in 2004–2008, the principal exporters being Brazil (50,000 t), Kenya (19,000 t), Tanzania (16,000 t) and Madagascar (6000 t). The main importers were North Africa, Mexico, China, Portugal and Spain. The price of sisal on the world market has declined from US$ 713/t in 1979 to US$ 519/t in 1987, it remained stable at about US$ 550/t until the year 2000, but has risen again in nominal terms in recent years to about US$ 592/t. Sisal from East Africa, where the crop is mainly grown on estates, is of better quality than that from Brazil, where it is mainly produced by smallholders, and East African sisal fetches higher prices on the world market.

Properties Each sisal leaf contains (700–)1000–1200(–1400) fibre bundles which, as in other *Agave* species, can be distinguished into 2 main types:

– 'mechanical fibres', constituting 75% of the fibres in the leaf and mainly concentrated in 3–4 rows in the peripheral zone below the epidermis; these fibre bundles, nearly round or horseshoe-shaped in cross-section, keep the leaf rigid and rarely split during processing, thus being the main determinant of the fineness of the resulting fibre.

– 'ribbon fibres', constituting 25% of the leaf fibres, are found in a line in the centre of the leaf; they coalesce and become lignified towards the end of the leaf to form the terminal spine. They are also present in other parts of the leaf and serve to protect the vascular bundles; those covering the phloem are large and crescent-shaped and tend to split longitudinally during processing, whereas those covering the xylem are weak, thin-walled and are mostly lost during decortication.

The average fibre content of the leaves is about 3.5–4%, but it increases during the life cycle from about 2% to 4.5–5%. The fibre bundles are composed of fusiform cells, strongly bonded together. The ultimate fibre cells are (0.3–)1.5–4(–15) mm long and (8–)15–30(–50) μm in diameter, circular, polygonal or oval-polygonal in cross-section with cell walls (2–)4–6(–9) μm thick and a small, roundish lumen. The fibre cells may taper to a blunt point or be rounded. The fibre number, length and strength do not change with the age of the leaf after it has unfurled. However, the average strength of the fibres increases and the fineness decreases slightly with the age of the plant at which the leaf was formed. Sisal fibre is hard, coarse, long (1–1.5 m), very strong and nearly white, cream or pale yellowish. Quantitative information on the physical properties of the fibre shows wide variation in, for example, tensile strength (80–840 N/mm^2) and elongation at break (2–29%). Typical values of the properties of sisal fibre are: tensile strength 510–635 N/mm^2, elongation at break 2.0–3.0%, and Young's modulus 9400–22,000 N/mm^2. Sisal can be used for making sacks, but cannot be spun as fine as jute. On a dry weight basis sisal fibre contains approximately 54–66% α-cellulose, 12–17% hemicelluloses, 7–14% lignin, 1% pectin and 1–7% ash.

Sisal pulp has an exceptionally high tear strength, good porosity, high bulk, high absorbency and high folding endurance, making it suitable for specialty papers and for reinforcing other pulps. Sisal is best pulped using chemical methods. Normally the cold soda process is used, because it is relatively cheap and produces no harmful chemicals. The yield with this process is 50–55%. Sisal fibre is also suitable for making high-quality fibreboard. Pulped fibre is suitable as reinforcement in composite boards, e.g. in boards made from cardenol, a polyphenol from the shells of cashew nuts, a major product of East Africa and Brazil.

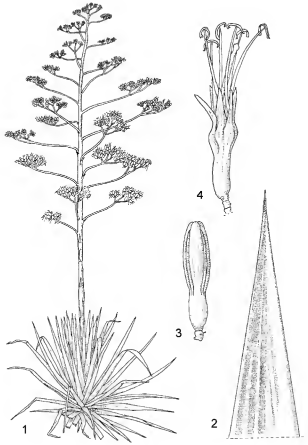
Sisal contains several steroidal saponins including hecogenin, its content increasing with the age of the plant. Hecogenin from sisal can be used in the partial synthesis of corticosteroids, but only if it is not overly contaminated by tigogenin, another sapogenin, because this results in unacceptable losses in product quality and yield. East African sisal yields relatively clean hecogenin with only 5–10% tigogenin, but sisal from other parts of the world often contains more tigogenin, e.g. 20–30% in Brazil. Pulp from sisal leaves has shown strong molluscicidal activity against the schistosomiasis vector *Biomphalaria glabrata*.

The value of waste material from sisal leaves after fibre extraction as animal feed has been analysed in Ethiopia. Dry matter content of the fresh waste was 82 g/kg; per 100 g dry matter sisal waste contained: crude protein 6.4 g, ash 17.7 g, ether extract 1.6 g, neutral detergent fibre (NDF) 33.3 g, acid detergent fibre (ADF) 26.9 g, lignin 14.2 g, total phenolics 1.0 g, total tannins 0.2 g, condensed tannins 0.01 g, phytate 2.0 g, saponins 0.08 g. Other analyses indicate a protein content of sisal waste of about 5–6% and that of the bole of only about 2%. The bole is rich in inulin, which makes it difficult to dry for industrial processing e.g. into fuel-alcohol. Experiments in East Africa indicate that the waste material from the leaves after fibre extraction is a suitable source material for fermentation and distillation into fuel-ethanol.

Adulterations and substitutes Abaca (*Musa textilis* Née) and henequen (*Agave fourcroydes* Lem.) may substitute for sisal or mixed with it. Compared to abaca, sisal ropes are less strong, harsher on the hands, swell more and quicker in water without regaining their shape on drying, and tend to break without warning, whereas abaca will show signs when it starts to break. For these reasons and because sisal ropes become stiff when wet and do not float, sisal is less suitable for marine purposes than abaca. Cantala (*Agave cantala* Roxb.) fibre is less strong than sisal fibre, but finer, more supple and whiter. Fibres from New Zealand hemp (*Phormium tenax* J.R.Forster & G.Forster), Mauritius hemp (*Furcraea foetida* (L.) Haw.) and *Sansevieria* spp. are softer than sisal fibre and may be used instead of sisal for specific purposes. Sisal and other hard fibres face strong competition from synthetic products, such as polypropylene and nylon.

Sisal is more difficult to pulp than abaca, as it requires a higher pressure, longer cooking time and/or more chemicals. Furthermore the pulping yield of sisal is lower. Because sisal fibre cells are shorter than those of abaca, paper made from sisal has a higher porosity but lower tensile and bursting strength than paper made from abaca. Therefore, sisal is inferior to abaca for the production of specialty papers, except for filtration media.

Description Robust, monocarpic, perennial herb, 3–9 m tall when flowering, with numerous leaves crowded in a dense rosette; roots fibrous, originating from the base of the leaf scars at the bottom of the stem, spreading horizontally up to 3(–5) m, and vertically up to 150 cm, but concentrated in the upper 30–40 cm of the soil; stem short and thick, 120 cm × 20 cm, with an apical meristem; rhizomes arising from buds in the axils of leaves below ground level, numbering 5–10 at one time and about 20 in the total life span, 1.5–3 cm in diameter, growing to about 2 m in length before surfacing and producing suckers. Leaves succulent, arranged in an ascending spiral; stipules absent; petiole absent; blade linear-lanceolate, 75–185 cm × 10–15 cm × 2–4.5 cm, base fleshy, bulbous, triangular in cross section, blade gradually broadening to the middle and narrowing into a terminal sharp, lignified, dark brown spine up



Agave sisalana – 1, habit flowering plant; 2, apical part of leaf; 3, flower bud; 4, flower.
Source: PROSEA

to 3 cm long, concave above and convex below, margin usually spineless, surface dark green but covered with a white waxy layer. Inflorescence a panicle on a long peduncle, 2–8 m tall, branches widely spreading, 30–100 cm × 2 cm, apically 5–6 times branched trichotomously, bearing about 40 flowers per branch. Flowers erect, protandrous; pedicel short; perianth tubular, 6-lobed, 5–6 cm long, pale green, tube 1–2 cm long, lobes oblong, on inner side of the top with a tuft of hairs; stamens 6, attached above the middle of the perianth tube, accrescent during anthesis, finally 6–8 cm long; ovary inferior, 3-celled, style much accrescent during anthesis and finally 6–8 cm long, stigma 3-lobed. Fruit (rarely produced) an ellipsoid capsule, tapering at base, green and fleshy when young and black and dry when ripe, with about 150 seeds. Seeds rounded-triangular, thin, flat, papery, black. Bulbils copiously produced on the inflorescence branches, consisting of a meristem, 6–8 reduced leaves and a rudimentary stem with rudimentary adventitious roots.

Other botanical information *Agave* comprises about 275 species distributed mainly in arid and semi-arid regions from the south-western United States southward to western Panama, the Caribbean and Venezuela. The taxonomy of the genus is very complicated and the genus has been subdivided into several subgenera and sections. However, different views exist on delimitation and classification of *Agave*. The long-fibre cultivated species are all classified in subgenus *Euagave* section *Rigidae*, except *Agave sisalana* which is classified in section *Sisalanae*. The basic chromosome number of the genus is $x = 30$, and it contains diploids, triploids, tetraploids and pentaploids. In Central America, where the genus probably originated, *Agave* has been used by humans as a source of food, drink and fibre for at least 9000 years.

Agave sisalana, the original and long the most important of the long-fibre *Agave* crops on a world scale, is probably of hybrid origin, with *Agave angustifolia* Haw. and *Agave kewensis* Jacobi as possible parents. In the 1960s in Kenya a chance selection was made from *Agave sisalana* and developed into cv. 'Hildana'. It is characterized by a large habit, many but shorter leaves and delayed flowering. It is grown in East Africa. Most other long-fibre *Agave* cultivars also derive at least partly from *Agave angustifolia*, a species classified in the section 'Rigidae'. Together they account for about 85% of the hard fibres of commerce. Hybrid 11648, released in Tanzania in 1960, was obtained by backcrossing a hybrid of *Agave amaniensis* Trel. & W.Nowell and *Agave angustifolia* with *Agave amaniensis*. Because of its high yield, it has largely replaced *Agave sisalana* in Tanzania in spite of its susceptibility to diseases and waterlogging. Commercially no distinction is made as its fibre is similar to that of *Agave sisalana*. Also in the literature on the agronomy, processing and properties of sisal, the distinction is rarely made. However, reports in Kenya indicate that its pulp yield is somewhat lower and the pulp slightly less strong. Little information exists on the extent to which this hybrid has replaced *Agave sisalana* elsewhere, but it is widely planted in Kenya and Brazil, and has played an important role in the expansion of sisal production in China. *Agave amaniensis* is a diploid, with sword-shaped leaves c. 165 cm long, very glaucous blue, thick at the base and tipped with a reddish brown spine. It is originally described from plants introduced to and cultivated in Amani (Tanzania).

Kaptura is the name given to short sisal plants occurring on many estates. They are characterized by short, slender, light bluish-green leaves, an expanded growth habit with a short central spike, a low fibre yield (30–50 m of leaf is required to produce one tonne of fibre, compared with the usual 13–15 m) and high sucker production (4 times that of Hybrid 11648). Kaptura plants have been identified as Hybrid ML 487, which was bred at Mlingano but later identified as being inferior to other hybrids, and was therefore never officially released.

Other *Agave* species grown for their long fibres, include henequen (*Agave fourcroydes*), the second most important species. It is only grown in Mexico and some Central American and Caribbean countries, with Mexico and Cuba as main producers. It has been suggested that it is an old selection from *Agave angustifolia*. The fibres of henequen are coarser than sisal. They are used for production of ropes, nets, floor-covering and harvest binding strings. The plants are cultivated also as hedges and living fences, e.g. in Cuba and are used for medicinal purposes. *Agave angustifolia* var. *letonae* (Taylor ex Trel.) Gentry (synonym: *Agave vivipara* var. *letonae* (Taylor ex Trel.) P.I.Forst.) produces the Salvadorian henequen hemp of El Salvador. *Agave cantala*, yielding cantala or Maguey sisal, is also classified in the section *Rigidae*, but not directly related to *Agave angustifolia*. It is of importance as a fibre crop in the Philippines. *Agave cantala* has been grown in Tanzania, but plants flowered too early and suffered from diseases.

Growth and development Sisal plants have a short stem or bole on which the leaves and the central bud (often called 'spike') are borne. In the central bud immature white leaves are packed tightly around the meristem until they are pushed outwards by the growth of succeeding leaves and unfurl. The angle between unfurling leaves and stem gradually widens until the lower leaves are almost horizontal. After having produced (180–)200–250(–300) leaves, which may be up to (3–)6–9(–20) years after planting depending on climate and soil conditions, a long flowering shoot ('pole') is produced. Its initial growth rate is 10–12 cm per day. In Java poles are formed throughout the year, but in more seasonal climates there is usually a flush of pole formation after the rainy season. After the pole has reached its final length, flowering branches are produced. Flowering starts on the lowest branch and proceeds upwards, taking several weeks until all branches have flowered. The stamens dehisce 2–3 days before the style is fully elongated and the stigma is sticky and receptive. When female flowering takes place on a branch, the stamens on the branch above it shed pollen. Pollination is mostly by insects, mainly bees, but wind-pollination can also occur. Although the pollen of *Agave sisalana* is viable, the flowers usually abscise. Where it has produced seed, this is probably due to contact with pollen from *Agave angustifolia* or related species. It has also been suggested that fruiting depends on external conditions. Seeds have been obtained in the Kenyan highlands, Indonesia and Brazil by cutting back the inflorescence in an early stage of its development, but this technique was not successful at lower altitudes in East Africa. Bulbils are normally formed on the panicle after the flowers are shed and usually appear in the bottom branches of the pole before the upper flowers have finished flowering. The bulbils grow to a length of 6–10 cm in about 3 months, after which they are shed. One plant can produce up to 4000 bulbils. After the production of flowers and bulbils the entire plant dies. However, a sisal plant may produce 20 or more suckers during its life cycle. Suckers are formed at the end of rhizomes. They normally start to form when plants are about 1 year old, are most prolific in the 2nd and 3rd year and become fewer as the plants age.

During the initial vegetative phase of the sisal plant each new leaf is 0.6–0.8 cm longer than the preceding leaf. When leaves are regularly harvested the leaf length increase is less, but the rate of leaf unfurling remains almost the same. When sisal becomes reproductive, new leaves progressively become shorter. Based on these characteristics the life cycle can be divided into 4 phases: 1, the immature period from planting to first cut; 2, the period during which relatively short leaves are cut (usually the 1st and 2nd cut); 3, the period during which long leaves (about 120 cm) are harvested; 4, the period just before poling, when leaves are becoming shorter.

Sisal follows the Crassulacean Acid Metabolism (CAM) pathway. CAM plants are able to fix CO_2 at night and photosynthesize with closed stomata during the day, thus minimizing water loss. A mature sisal plant, excluding roots, weighs about 60 kg. On a dry weight basis the leaves constitute 70%, the roots 22% and the bole 8% of an unharvested plant. An average leaf weighs about 0.7 kg.

Ecology Sisal is a hardy tropical plant needing full sunlight and moderate relative humidity. It grows best in regions with an average annual rainfall of 1000–1250(–1800) mm, but is often grown with less. The maximum temperature should be 27–32°C, with minimum temperatures of 16°C or higher and daily fluctuations not exceeding 7–10°C. Sisal is damaged by frost and hail. Under dry conditions or at low average temperatures it forms fewer leaves per year and has a longer life cycle. In tropical Africa it is grown up to 1800 m altitude.

Sisal prefers sandy-loam soils but can be grown on a range of soils, provided they are rich in bases, especially Ca, and well drained, as sisal does not tolerate waterlogging. The pH should be between 5.5 and 7.5, though sisal has been grown on soils with pH 4–5. Hybrid 11648 does not tolerate waterlogging.

Propagation and planting Sisal is propagated vegetatively with bulbils or suckers. Though suckers are directly available from the field, bulbils are often preferred, because they are produced in greater numbers, making selection possible and thus giving a more uniform crop. Bulbils may be collected from the ground after they have fallen, or the pole may be cut and the bulbils shaken into sacks. In very dry years bulbils may be in short supply. Bulbils at least 10 cm long are planted in nurseries at a spacing of about 50 cm × 25 cm and a depth of 1.3 cm. Application of sisal waste in the nursery is beneficial to plant growth. After 12–18 months the plants are ready to be planted out into the field. At transplanting the fibrous roots around the base of the plantlets are usually cut off and the lower leaves may be pulled off.

Before planting in the field, the soil is cleared mechanically or by hand and it may be ploughed shallowly. The optimum density is 4000–6000 plants/ha, depending on climate and soil. Most sisal estates in East Africa have a density of 5000 plants/ha, obtained by a spacing of 2.5 m × 0.8 m or by double rows 3.5–4 m apart, with 1 m between the rows of each pair and (0.75–)0.8(–1) m between plants within each row. A density of 7000 plants/ha has been mentioned for sisal grown for pulping in Brazil. The planting depth is 5–8 cm.

In-vitro propagation of sisal is possible, as complete plants have been regenerated from rhizome and stem explants on various growth media, supplemented with various concentrations of plant hormones, e.g. benzyladenine (BA), kinetin, naphtalene acetic acid (NAA), indolacetic acid (IAA), indolylbutyric acid (IBA) and 2,4-D, either alone or in combination. Shoot regeneration may occur either directly or from callus, and regenerated shoots root readily.

Sowing of legume cover crops such as *Calopogonium mucunoides* Desv., *Centrosema pubescens* Benth. and *Pueraria phaseoloides* (Roxb.) Benth. is recommended. On fertile soils or with proper fertilization, young sisal may be intercropped with maize, beans or cotton without adverse effects on the sisal crop unless the other crops are planted very close to the sisal rows. Rotation is not necessary if sisal processing waste is returned to the field and is not commonly practised in East Africa.

Management Weeds should be controlled in the first 2–3 years after transplanting, by hand, or by mechanical or chemical means. Important weeds in sisal plantations include: couch grass (*Cynodon dactylon* (L.) Pers.), nut grass (*Cyperus* spp.), African couch (*Digitaria abyssinica* (Hochst. ex A.Rich.) Stapf), lalang (*Imperata cylindrica* (L.) P.Beauv.), cow-itch (*Mucuna pruriens* (L.) DC.) and Guinea grass (*Panicum maximum* Jacq.). After 2–3 years, weeds may be allowed to grow during the rains and cut down at the beginning of the dry season to conserve moisture and provide mulch. The nutrient removal per t of fibre is about 27–33 kg N, 5–7 kg P, 59–80 kg K, 42–70 kg Ca and 34–40 kg Mg, but the majority of the removed nutrients can be returned to the field with the waste material after fibre extraction. Fertilizer recommendations depend on soil characteristics and cropping history. Lime application is recommended in highly acidic soils. 'Purple leaf tip', in which the leaf tip becomes reddish-purple and the leaf margins curve upwards, is associated with exhausted acid soils and a shortage of calcium, but other factors may also be involved. Potassium deficiency causes 'banding disease', characterized by 10–15 cm wide horizontal bands of purplish-brown necrotic tissue, especially at the transition between the leaf base and the leaf blade, resulting in wilting and bending over of the leaf blade. Nitrogen application tends to shorten the crop cycle, but the total number of leaves is not affected. Care should be taken in using ammonium sulphate which may increase soil acidity. Suckers should be removed and may be used for propagation. Old sisal fields are sometimes kept in production by maintaining selected suckers, but this method is not recommended as it is better to replant the field.

Diseases and pests The most serious disease of sisal is bole rot caused by the fungus *Aspergillus niger* entering through the leaf bases after leaves are cut. It causes a wet rot which becomes yellowish-brown and soft, with a pinkish margin, and it may lead to plant collapse and death. The incidence can be reduced through removal of infested material and harvesting under dry conditions. The fungus also causes a basal dry rot when it enters the base of the bole through an injury. Zebra disease causes striped lesions on the leaves and may also cause bole rot. It is caused by *Phytophthora nicotianae* and mainly occurs on poorly drained soils. Hybrid 11648 is especially vulnerable. Korogwe leaf spot is a virus disease occurring in Tanzania which gives very poor grade fibre and often renders the crop unusable. Hybrid 11648 is very susceptible to this virus disease, *Agave sisalana* only slightly.

The only serious insect pest of sisal is the agave weevil or Mexican sisal weevil (*Scyphophorus acupunctatus*; synonym: *Scyphophorus interstitialis*), first recorded in Tanzania in 1914. The larvae damage the subterranean parts of young plants and may cause substantial losses. They also feed on leaves in the central bud, giving a shothole effect, whereas the adult weevil damages the crop by feeding on the youngest leaves before and shortly after unfurling. Planting before or in the early rains and the application of insecticides in the soil around young plants can control the pest.

Harvesting Sisal leaves are harvested at regular intervals during the life cycle of the crop. As the total number of leaves produced during the life of the plant is constant and the rate of leaf emergence is affected by temperature and rainfall, the time from planting to the first harvest, the total production period and the number of cuttings depend on environmental conditions. An early start of cutting is conducive to better yields, provided the plants are not cut too severely. If cutting is delayed, plants pole earlier and heavy leaf losses occur through withering. Overcutting results in the formation of more but smaller leaves with lower fibre content, leading to reduced fibre yields and higher cutting costs. In general the first harvest takes place when leaves over 60 cm long start to touch the ground. Leaves shorter than 60 cm are normally not used for fibre extraction, because mechanical decorticators cannot handle them. The time from planting to the first harvest depends on the rate of leaf production, which in turn depends on climate and soil conditions. Under East African lowland conditions (high temperature) cutting usually starts 2–3 years after planting and cutting is then repeated annually. In the Kenyan highlands (lower temperature) cutting usually starts 4 years after planting. In Brazil (low rainfall, low soil fertility) the first harvest usually takes place when the plants are 3 years old and subsequent harvesting is twice a year. Generally harvesting continues for about (5–)8(–12) years. At the last cutting, when about 80% of the plants are poling, all suitable leaves (more than 60 cm long and sufficiently succulent) are cut. Harvesting is usually done throughout the year.

Leaves are usually cut manually at 2.5–5 cm from the bole. It is essential to leave sufficient leaf area at each cutting to enable the plant to continue growing. About 20–25 leaves are left on the plant at the first cutting, and this number is usually decreased to 15–20 leaves at subsequent cuttings. The terminal spines are removed before or after the leaves have been cut. The leaves are tied in bundles and transported to the processing site, which must be done as soon as possible after harvesting, because cut leaves deteriorate rapidly if exposed to the sun.

Mechanization of leaf cutting is complicated and not economical, but gains can be made in transportation of the leaves to the mill.

Yield From 100 kg sisal leaves about 3.5 kg extractable fibre is obtained, of which about 92–96% is line fibre and 4–8% tow. For the best Chinese plantations annual yields of 4.5 t/ha are claimed. On East African plantations annual fibre yields of 2.0–2.8 t/ha have been obtained, whereas on poorer soils annual yields were about 1 t/ha. Yields in Tanzania have shown a strong downward trend since the 1960s, but they have recovered since. Average annual fibre yields in Brazil, Kenya and Tanzania are now nearly 1 t/ha. Sisal processed for pulp production in Brazil yields about 5.5 t of dried fibre per ha per year, with 6 kg of fibre obtained per 100 kg fresh leaves.

Handling after harvest Fibre extraction of sisal should be carried out as soon as possible after cutting, because leaf juices tend to harden, making fibre extraction more difficult. Where sisal is grown for local use, the fibre is manually extracted by scraping away the leaf parenchyma with a blunt knife or piece of wood. Retting is also done, e.g. in India, where the leaves are immersed in water for about a week, after which the leaves are beaten on a stone to remove the remaining extraneous matter, and the separated fibre is washed, dried in the sun and baled. In commercial production, decortication is usually mechanical. Before the advent of high-speed automatic decorticators this was done by semi-automatic raspadors, consisting of 1–4 open rotating drums with blades or bars on the periphery, into which the leaves are fed manually and end-on. Decorticators consist of decorticating drums, chains or rope for leaf-gripping and belts, into which the leaves are fed sideways, and have a much higher productivity than the raspador. Extraction with decorticators involves crushing and scraping, removing and washing away the parenchymatous leaf tissue and leaving the fibre strands to continue through the machine. During decortication 15–20% of the total leaf fibre ('flume tow') is lost and enters the waste effluent. Mobile decorticators have been introduced into Tanzania. After decortication and washing, the fibre is dried, either in the sun or in drying machines, the latter giving fibre of a more uniform quality. Excessive drying in the sun may lead to deterioration in colour. The dried fibre, which has become stiff and congealed, may be beaten lightly by metal beaters ('brushing') to free the individual bundles and to remove dirt and other extraneous matter. This process also combs out the shorter fibre strands, 7.5–12.5 cm in length, which constitute the 'brush tow'.

Sisal fibre is mainly graded according to length, colour and presence of impurities, but designations vary by country and even within countries. The moisture content of packed fibre should not be more than 10–12%. If it is too wet, it becomes stiffly matted and there is a danger of spontaneous combustion in the bales. The fibre is baled in hydraulic presses to produce unwrapped bales of the desired size. Spinning of yarn is usually done on special machines able to cope with the long fibres. The yarns produced are coarse, spiky and harsh to the hands. They are used singly as harvest twine, 3-folded into packaging twine or further multiplied into ropes of different sizes. Processing sisal fibre may cause lung problems in factory workers.

For paper production in Brazil, the leaves, with the terminal spine removed, are transversely cut into pieces about 5 cm long and passed through a hammer mill. The juice and other residues are removed through vertical screens; the fibres are passed through a dryer, after which they are pulped using an alkaline soda process.

To obtain hecogenin, sisal leaf juice collected from the decorticator is allowed to ferment for several days, after which the sludge is hydrolysed into a dark brown solid ('coffee grounds') with a hecogenin content of 10–20%. Alternatively, air is blown upwards through a tank containing fresh juice, and the resulting foam, containing most of the saponins, is transferred to a vessel for immediate hydrolysis to hecogenin.

Genetic resources About 70 sisal accessions are kept at the Centro Nacional de Pesquisa de Algodão (CNPA), Campina Grande, Brazil. The Instituto Agronômico de Campinas (IAC), Campinas, São Paulo, Brazil, maintains a collection of about 300 *Agave* accessions. Germplasm is also kept at the Mlingano Agricultural Research Institute in Tanzania.

Breeding Sisal has a narrow genetic base and offers little opportunity for breeding and selection. Furthermore, the plants have a long life cycle and it is almost impossible to synchronize flowering of prospective parents. Most breeding work has been carried out in East Africa, where it focused on developing a long-fibre *Agave* with a more rapid growth and higher leaf number potential than sisal, but resembling sisal in other respects (non-spiny leaf margins; long, heavy and rigid leaves of good configuration; good fibre yield per leaf; resistance to diseases and pests; good fibre quality). Several *Agave* species have been incorporated in sisal breeding. Examples are the diploids *Agave amaniensis*, which has smooth margins and finer and more numerous fibre bundles in its leaves than *Agave sisalana* but has leaves tending to be corrugated, making mechanical processing difficult, and *Agave angustifolia*, which produces many but short leaves with spiny margins. Crosses between *Agave sisalana* and these species resulted in progenies with spiny margins, but crosses between *Agave amaniensis* and *Agave angustifolia* are fertile and combine a high number of leaves with a good leaf size, some of them having smooth margins. Backcrossing of these hybrids with *Agave amaniensis* gave very good results, in particular Hybrid 11648, which may produce more than 600 leaves and give annual fibre yields twice as high as sisal, with a longer life cycle. The leaves are of good configuration and have smooth margins, and the fibre is as strong as sisal fibre, though finer. However, Hybrid 11648 is susceptible to zebra disease caused by *Phytophthora* spp., to which *Agave sisalana* is mainly resistant. At altitudes higher than 600 m the leaves are short and the leaf-number potential is not realized because of early poling. Other cultivars released in Tanzania include 'H-1300' and 'Mlola 1', which is grown in Kenya.

New cultivars have been released in China, such as 'South Asia No.1' and 'South Asia No.2'. These new cultivars are resistant to zebra disease while maintaining similar fibre production as Hybrid 11648 and outweighing it in terms of fibre quality and cold resistance. Breeding work in Brazil focussed on backcrosses between *Agave amaniensis* and hybrids of *Agave amaniensis* and *Agave angustifolia*. Successful crosses between sisal and cantala have been made, e.g. in Indonesia, but usually seed set is poor and the progeny has spiny leaf margins.

Prospects There is scope for increased utilization of sisal, including agaves such as Hybrid 11648, in view of the resurgence of demand for natural fibres for their biodegradability and unique appearance and texture. Non-traditional uses of sisal and sisal-like fibre, especially for the production of pulp, offer promising new possibilities for producers. The development of highly productive cultivars suited to local needs, improved management practices, efficient fibre extraction and pulping technologies and further promotion of the use of natural fibres may open a new frontier to the profitable cultivation of sisal in tropical Africa.

However, labour shortages due to low wages paid in sisal plantations may hamper developments. The development of mechanical harvesting methods would enhance their prospects as fibre crops, especially if it could be combined with fibre extraction. Better utilization of the by-products (short fibres, poles and boles for pulping; leaf waste for feed or hecogenin extraction) would help to make their cultivation more profitable.

Major references Dahal, Utomo & Brink, 2003; Deckers, Ngatunga & Msafiri, 2001; Gentry, 1982; Hartemink & Wienk, 1995; Kimaro, 1994; Lock, 1969; McLaughlin & Schuck, 1991; UNIDO & CFC, 2005; Wienk, 1995; Wood, 1997.

Other references Barreto et al., 2011; Bisanda & Enock, 2003; Chen et al., 2011; FAO, 2004; Garcia-Mendoza & Chiang, 2003; Gillah, Irle & Amartey, 1998; Harkonen, Saarimaki & Mwasumbi, 1994; Hartemink, 1997; IENICA, 2007; Kayumba et al., 2011; Keswani & Mwenkalley, 1982; Kirby, 1963; Lwoga, 1987; Majaja & Chancellor, 1997; Mbuya et al., 1994; Msafiri, 1987; Ndabaneze, Engels & Kavamahanga, 1996; Negesse, Makkar & Becker, 2009; Robert et al., 2008; SAGI, undated; Temu & Due, 1998.

Sources of illustration Dahal, Utomo & Brink, 2003.

Authors L.P.A. Oyen

Based on PROSEA 17: Fibre plants.

ALAFIA NIGRESCENS Pichon

Protologue Bull. Jard. Bot. Etat 24: 148, f. 16 (1954).

Family Apocynaceae

Origin and geographic distribution *Alafia nigrescens* is endemic to northern Madagascar.

Uses The long stems provide a tenacious binding material traditionally used in the construction of houses and bridges.

Production and international trade The stems are only used locally.

Botany Large, laticiferous liana. Leaves opposite, simple and entire; petiole 3.5–7 mm long, base broadened and surrounding the stipules; stipules forming a semi-collar; blade elliptical, 6–11 cm × 3–4.5 cm, base somewhat rounded and angular, apex acuminate, thin, lateral veins in 7–10 pairs, straight, connected by a submarginal vein. Inflorescence a few-flowered, lax, terminal cyme on an indeterminate flowering branch; peduncle 1–7 mm long; bracts c. 1 mm long. Flowers bisexual, regular, 5-merous; pedicel 2.5–4 mm long; sepals ovate, 1.5–2 mm long, with stipitate glands on the inside; corolla white, tube cylindrical, 5.4–6.7 mm × 1.5 mm, base swollen, narrower at the throat, with 5 thickened bands from throat to base of lobes, lobes linear-oblong, 6–8 mm × 1.5–3 mm; stamens inserted at base of corolla tube, filaments short, anthers arrow-shaped, 3–4 mm long; ovary superior, of 2 free carpels, broadly conical, c. 0.8 mm long. Fruits unknown.

Flowering occurs from October to December.

Alafia comprises 23 species, 15 of which occur in continental Africa and 8 in Madagascar.

Ecology *Alafia nigrescens* occurs from sea-level up to 500 m altitude in shady or open places in dry to humid forest.

Management *Alafia nigrescens* only occurs wild. The stems are sometimes passed through fire before use.

Genetic resources and breeding *Alafia nigrescens* is a rare plant, collected from only a few locations. However, it is not listed in the IUCN Red list. It is protected in two conservation areas.

Prospects Little is known about *Alafia nigrescens*, making it difficult to assess it prospects. It is likely, however, that the plant will remain of occasional local importance only.

Major references Boiteau, Boiteau & Allorge-Boiteau, 1999; Leeuwenberg, 1997; Markgraf, 1976.

Other references Pichon, 1954; Watson & Dallwitz, 1992–.

Authors L.P.A. Oyen

ANADELPHIA AFZELIANA (Rendle) Stapf

Protologue Fl. Trop. Afr. 9: 397 (1919).

Family Poaceae (Gramineae)

Chromosome number $2n = 20$

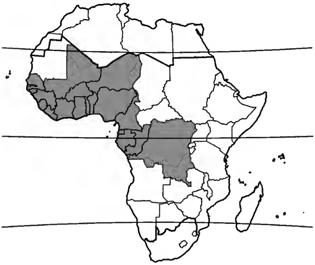
Synonyms *Andropogon afzelianus* Rendle (1893), *Anadelphia arrecta* (Stapf) Stapf (1919), *Pobeguinea afzeliana* (Rendle) Jac.-Fél. (1950), *Hypogynium arrectum* (Stapf) Roberty (1960).

Vernacular names Thatch grass (En).

Origin and geographic distribution *Anadelphia afzeliana* occurs from Senegal eastward and southward to DR Congo.

Uses The stem is used for thatching. In parts of West Africa it is cultivated for this purpose. Young growth is grazed.

Production and international trade *Anadelphia afzeliana* is only used locally.



Anadelphia afzeliana – wild

Properties Thatching material from *Anadelphia afzeliana* is of high quality. In the Northern Province of Sierra Leone it has even been described as the best thatching material available. The plant has a very low silica content. It is a forage of moderate quality.

Botany Perennial, tufted grass; tufts small, up to 5 cm in diameter; stems up to 2(–2.5) m tall, terete, leafy, branched, rather stout below, glabrous, 5–6-noded. Leaves alternate; sheath clasping the culm, hairy but base glabrous; ligule a ciliolate, membranous rim c. 1 mm wide; blade linear, up to 40 cm × 0.5 cm, long-tapering to a fine point, scabrid, midrib white, slender below, wider above, lateral veins numerous, close. Inflorescence compound, paniculate, 25–45 cm long, lax; branches bearing racemes with spikelets; raceme enclosed by a linear, 2–3.5 cm long, membranous spatheole, single, 1.5–2 cm long, bearing 2 sessile and 3 pedicelled spikelets; rachis internodes filiform, 4–5 mm long. Pedicelled spikelets sterile or male, linear to lanceolate, 6–9 mm long, callus oblong and 2-toothed, glumes coriaceous, 7–9-veined, glabrous, lemmas 2, enclosed by glumes; sessile spikelets fertile, lanceolate, subterete, 5–8 mm long, comprising 1 basal sterile floret and 1 fertile floret, callus linear, 1.5–2.5 mm long, pilose, glumes dissimilar, exceeding apex of florets, shiny, lower glume oblong, coriaceous, dark brown, 6–7-veined, upper glume oblong, 1–3-veined, margins ciliate, apex obtuse, with 8–15 mm long awn; lemma linear, 4–6 mm long, hyaline, apex 2-fid, with 25–40 mm long awn, palea absent or minute, stamens 3, stigmas 2. Fruit a caryopsis (grain).

In Benin flowering occurs from May to February.

Anadelphia is a genus of the *Andropogoneae* and comprises 14 species. The genera *Pobeguinea* and *Monium* are sometimes included in *Anadelphia* which then comprises c. 20 species. *Anadelphia bigeniculata* Clayton is an annual grass 30–60 cm tall, growing on ironstone outcrops in Guinea and Sierra Leone. It is used for thatching and as forage. *Anadelphia leptocoma* (Trin.) Pilger is a perennial grass with stems up to 1.5 m tall, occurring in low-lying savanna from Mali to Gabon. It is called thatchgrass in Sierra Leone and is used as a substitute for *Anadelphia afzeliana*, but is considered of poorer quality. It is thought to be suitable for the revegetation of tailings of titanium mines. *Anadelphia trepidaria* (Stapf) Stapf is an annual grass with 30–60 cm long stems, occurring in Guinea. It is probably used for thatching and as forage.

Ecology *Anadelphia afzeliana* occurs mainly in the Sudanian zone. It is locally dominant near waterholes and in low-lying regularly flooded and poorly drained wetland savanna. In Senegal it is dominant in savannas receiving 900–1100 mm annual rainfall in a wet season of 5–7 months; in southern Côte d'Ivoire it occurs in the coastal zone in drier savannas.

Genetic resources and breeding *Anadelphia afzeliana* is widespread and common and not in danger of genetic erosion. There are no accessions of *Anadelphia afzeliana* in genebanks.

Prospects *Anadelphia afzeliana* is likely to remain an occasional source of thatch and fodder.

Major references Burkill, 1994; Clayton, 1966b; Clayton, Harman & Williamson, 2002–; Stapf, 1917–1934; van der Zon, 1992.

Other references Adjanohoun, 1962; Akoègninou, van der Burg & van der Maesen, 2006; Catarino, Martins & Moreira, 2001; Diallo et al., 1968; Jacques-Félix, 1950; Kammacher et al., 1973; Le Houérou, 1973; Poilecot, 1999; Valenza & Fayolle, 1965; Whyte, 1974.

Authors A.J. Bagué Serrano

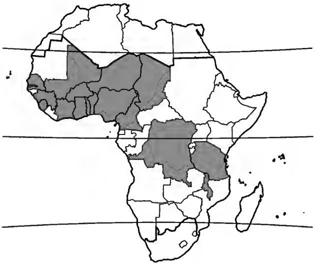
ANDROPOGON PSEUDAPRICUS Stapf

Protologue Prain, Fl. Trop. Afr. 9: 242 (1919).

Family Poaceae (Gramineae)

Chromosome number $n = 20$

Origin and geographic distribution *Andro-*



Andropogon pseudapricus – wild

pogon pseudapricus is distributed from Senegal and Mauritania eastward to Chad, and occurs scattered in DR Congo, Tanzania and Malawi. It has probably been introduced in Mexico and Brazil.

Uses The stems of *Andropogon pseudapricus* are widely used for thatching. In Nigeria they are chopped, mixed and puddled with clay to make building blocks. In Mali *Andropogon pseudapricus* is one of several grasses used for making mats and screens, and it is commonly sold in markets in Bamako for this purpose. The plant is grazed by stock, especially when still young. It is also valued as hay during the dry season and in Senegal the aftermath is considered especially useful. The seeds are eaten in Mali in times of famine.

Production and international trade The stems are traded in local markets.

Properties A crude protein content of 7.4% in the rainy season has been recorded.

Botany Annual or perennial, tufted grass; stems up to 150 cm tall, ascending, branched above, thin, pinkish yellow, glabrous, often broken. Leaves alternate; sheaths auricled, glabrous or rarely loosely pilose; ligule truncate, up to 2 mm long, membranous, attached to the auricles, pinkish; blade linear, 8–40 cm × 1–5 mm, flat or rolled-in, glabrous or sparsely hairy, margins rough. Inflorescence a 30–60 cm long false panicle, copiously branched, bearing linear spathes and paired racemes; the pairs initially embraced below by spatheoles and later exserted from them; spatheoles linear to narrowly lanceolate, c. 5 cm long, reddish; peduncles at least as long as long the racemes, erect at maturity; racemes 2–4 cm long, flexible; internodes and pedicels cuneate to narrowly ellipsoid, ciliate with hairs c. 2 mm long. Spikelets in pairs, one sessile and fertile, one pedicelled and sterile; sessile spikelet 5–6 mm long, compressed between internode and pedicel, callus 1–2 mm long, obtuse, inserted in the concave top of the internode, white, bearded, lower glume linear, deeply depressed between the dorsal keels, glabrous, upper glume with an awn 5–16 mm long, lower floret reduced to a hyaline lemma, upper floret fertile, upper lemma bidentate, passing between the teeth into a geniculate awn 30–50 mm long, rarely less, stigmas 2; pedicelled spikelet sterile, narrowly elliptical, 4–5 mm long, membranous, glabrous to villous, 2-awned, the longer awn 5–11 mm long, the other much shorter. Fruit a caryopsis.

Andropogon comprises about 100 species. It occurs throughout the tropics, but is most prolific in Africa and the Americas.

Andropogon pinguipes Stapf is an annual, robust, purplish grass with erect stems 1–3 m tall, with a very narrow spatheate panicle up to 30 cm long. It is recorded only in West Africa from Senegal to Cameroon. The stems are used in Senegal as ties for thatch. In Mali they are used for thatching and for making mats, screens and doorway covers. They are traded in markets in Bamako (Mali). The plant is a good forage when young, and is browsed even when in flower.

Andropogon tenuiberbis Hack. is a perennial, robust, tufted grass with stems up to 5 m long and reddish or purplish inflorescences up to 60 cm long. It occurs in swamps and waterlogged locations from Senegal to Sudan, DR Congo and Tanzania. It is used for thatching and for making fences.

Ecology *Andropogon pseudapricus* is an important component of savanna vegetation in areas with an average annual rainfall of 500–700 mm, on shallow, sandy or gravelly lateritic soils. It is common on dry fallow land, often as a pioneer species. It occurs at 300–2100 m altitude. In Senegal it is also common on irrigation bunds and river-banks. In Burkina Faso, grazing increased its proportion in the vegetation in some locations, but had little effect elsewhere. Early fire had little effect.

Management *Andropogon pseudapricus* only occurs wild. In experiments it gave fodder yields of 15–18 t/ha when sown in rows.

Genetic resources and breeding *Andropogon pseudapricus* is widespread and sometimes a dominant component of savanna vegetation, and there are no indications that it is under threat of genetic erosion.

Prospects *Andropogon pseudapricus* is likely to remain of some importance as a material for thatching and for making mats and screens, and as a component of natural grazing land.

Major references Bogdan, 1977; Burkill, 1994; Clayton & Renvoize, 1982; Cope, 2002; van der Zon, 1992.

Other references Breman et al., 1979; Dujardin, 1979; Grivetti et al., 1987; Poilecot, 1995; Robyns, 1929; Savadogo, Sawadogo & Tiveau, 2007; Sawadogo, Tiveau & Nygard, 2005; Slingerland & Kiéma, 2001.

Authors L.P.A. Oyen

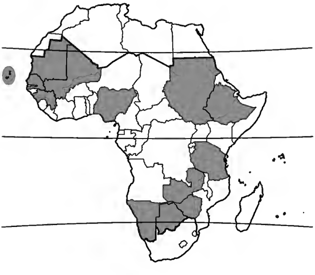
ARISTIDA STIPOIDES Lam.

Protologue Tabl. Encycl. 1(1): 157 (1791).

Family Poaceae (Gramineae)

Origin and geographic distribution *Aristida stipoides* is distributed across the Sahel from Cape Verde and Mauritania to Sudan and Ethiopia, and occurs scattered from Tanzania south-westward to Namibia.

Uses The stems are used for thatching and for making fences. They are also plaited to make mats and plates. The inner nodes are succulent and sweet, and are sucked by children, for instance in Cape Verde. Domestic animals will graze *Aristida stipoides*, but only when it is very young and for want of better browse. The plant is frequently galled, producing hard lumps of about 1.5 cm × 1 cm in the basal joint of a branch. Niominka doctors in Senegal consider these galls to be an excellent vermifuge, and Fulani doctors prescribe the galls powdered and mixed into food or taken by draught in water for anuria.



Aristida stipoides – wild

Production and international trade The stems are only used and traded locally.

Botany Annual, robust, laxly tufted, grass, up to 1.5 m tall; stems erect, simple or slightly branched from the upper nodes, glabrous, usually 3-noded; nodes glabrous. Leaves alternate; sheath slightly scaberulous or glabrous; ligule a short-ciliate rim; auricles with a tuft of woolly hairs; blade up to 30 cm × 3–5 mm, margins rolled inward when expanded or more or less flat at the base, prominently veined and scabrous above, smooth beneath. Inflorescence an up to 50 cm long panicle, spreading and very lax, often nodding, often few-flowered; branches glabrous or scaberulous, branchlets filiform; axis smooth. Spikelets solitary, 1-flowered, narrow, pedicelled, pallid or tinged with red or purple, especially at the base, sometimes with a black spot; rachilla disarticulating obliquely above the glumes; callus slender, c. 2 mm long, 2-toothed, bearded; glumes persistent, very unequal, 1-veined, glabrous, lower glume 5–7 mm long, broadly lanceolate, slightly 2-fid, minutely dented to hairy along the margins towards the apex, upper glume 15–20 mm long, narrowly linear with a mucro from a 2-fid apex; floret bisexual; lemma elliptical, 7–9 mm long, leathery, 3-veined, with 3 awns, the central one 3.5–6 cm long, the lateral ones a little shorter; palea one-tenth of the length of the lemma, without keels; stamens 3. Fruit a caryopsis.

Aristida is a large genus comprising nearly 300 species occurring worldwide, often in arid, warm regions. It is characterized by the 3-awned lemmas of the florets.

Aristida junciformis Trin. & Rupr. ('wire grass', 'Ngongoni three-awn grass') is a perennial, rhizomatous and tufted grass up to 90 cm tall and unbranched stems. It occurs from East to South Africa in savanna and grassland. Some of the grasslands of the eastern seaboard of South Africa are named after this grass ('Ngongoni Veld'). It is a very good grass for making brooms for domestic use. It has no value for grazing, as it is hard and unpalatable. Where selective overgrazing takes place, this grass forms dense stands which are very difficult to eradicate and it is considered a weed in these circumstances. It does create excellent ground cover which prevents soil erosion in the high altitude and high rainfall areas in which it occurs.

Aristida stipitata Hack. ('sandveld bristlegrass', 'dune bristlegrass') is a perennial, tufted grass with erect stems up to 150 cm long, occurring in tropical southern Africa. In the Okavanga delta in Botswana the stems are used for thatching. Sometimes stems are twisted into a tight bundle, immersed in water and lifted above the head so that the outflowing water can be drunk.

Ecology *Aristida stipoides* occurs on sandy and basaltic soils in grassland and scrub, also in peaty dambos. It is sensitive to heavy grazing. It is often indicative of impoverished soils.

Management *Aristida stipoides* only occurs wild.

Genetic resources and breeding *Aristida stipoides* is widespread and common and is not in danger of genetic erosion.

Prospects *Aristida stipoides* is likely to remain a grass of local importance for thatching and plaiting.

Major references Burkill, 1994; Clayton, 1970a; Clayton, 1972; Hiernaux, 1998; Launert, 1971.

Other references CIAT/FAO, undated-a; Clayton, Harman & Williamson, 2002–; de Winter, 1969; Gibbs Russell et al., 1990; Kerharo & Adam, 1964; Kgathi, Mmopelwa & Mosepele, 2005; Klaassen & Craven, 2003; Poilecot, 1999; van Oudtshoorn, 1999.

Authors L.P.A. Oyen

ATAENIDIA CONFERTA (Benth.) Milne-Redh.

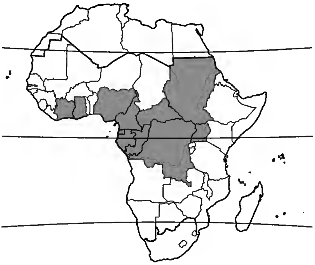
Protologue Kew Bull. 1952: 168 (1952).

Family Marantaceae

Synonyms *Phrynium confertum* (Benth.) K.Schum. (1902), *Ataenidia gabonensis* Gagnep. (1908).

Origin and geographic distribution *Ataenidia conferta* is distributed from Côte d'Ivoire eastward to Sudan and Uganda, and southward to DR Congo and Cabinda (Angola).

Uses The leaves are widely used for thatching and for wrapping things (especially food products) that need to be carried, cooked or kept. They are made into a range of articles, such as disposable plates, cups, pots, containers, funnels, fans and parasols, and they are used as cushion under sleeping mats. The stems are woven into baskets, granaries and stretchers for transport. In DR Congo the stem with a tip of a leaf is used for fishing freshwater crabs, and the leaves are used for marking paths in the forest.
In traditional medicine in Ghana a decoction of the root is rubbed on the chest for the treatment of whooping cough. In Cameroon the burnt and pounded root is mixed with palm oil and externally applied for the treatment of headache and sores. Bark scrapings are applied on swellings. In DR Congo a leaf decoction is used as an enema for the treatment of kwashiorkor (malnutrition caused by protein deficiency) and a maceration or decoction of the leaves is used in washings against haemorrhoids.


Ataenidia conferta – wild

Production and international trade In Cameroon bunches of leaves are locally traded.

Properties Wrapping food with the leaves of *Ataenidia conferta* is said to give the food a good aroma.

Botany Perennial herb with tufted habit and branched stems up to 1.5 m tall, forming tangles; rhizome short. Leaves distichous; petiole sheathing below, calloused just below the blade, calloused part up to 5 cm long; blade elliptical, asymmetrical, up to 48 cm × 20 cm, base attenuate to rounded, apex acuminate, upper surface glabrous, lower surface pubescent and often tinged reddish or purplish, veins parallel and numerous. Inflorescence 1 per stem, terminal but appearing to be axillary, surrounded by up to 6 leaves, spike-like, up to 4 cm × 4 cm, much branched, dense; branches with very short internodes and at each node a broadly elliptical, reddish-purple, persistent, abaxial bract c. 2.5 cm long subtending up to 4 cymules; cymules 2-flowered, with at the base 1 adaxial and 1 abaxial bract; peduncle of cymule c. 1 mm long. Flowers bisexual, zygomorphic, c. 2 cm long, pale pink or pale purple, sometimes white; pedicel c. 2 mm long; bracteole absent; sepals free, equal, 12–15 mm long;

corolla c. 20 mm long, tubular below, with 3 lobes; staminodes and stamen in 2 cycles, at the base forming a tube fused to the corolla tube, outer cycle consisting of 2 petaloid staminodes, inner cycle consisting of 1 stamen and 2 staminodes, of which 1 hooded without spur-like appendage; ovary inferior, pubescent, 3-locular. Fruit indehiscent, ellipsoid, c. 10 mm × 6–7 mm, membranous, red, not fleshy, with persisting perianth, 1–3-seeded. Seeds brown, with a white aril divided into 2 points.

Ataenidia is a monotypic genus. *Ataenidia conferta* is self-compatible, but depends on sunbirds for pollination. Natural reproduction is through seed, rhizomes and adventive shoots.

Ecology *Ataenidia conferta* occurs from sea level up to 1750 m altitude in wet places in dense primary and secondary forest.

Management *Ataenidia conferta* is usually collected from the wild. In Ghana it is sometimes planted, but details on propagation and management practices are not available.

Genetic resources and breeding As it is widely distributed and occasionally cultivated, *Ataenidia conferta* seems not to be in danger of genetic erosion.

Prospects *Ataenidia conferta* is a very useful fibre plant, yielding leaves for thatching and wrapping, and stems for weaving. Research on propagation and management practices may be worthwhile.

Major references Burkill, 1997; Hattori, 2006; Koechlin, 1965; Milne-Redhead, 1952; Terashima & Ichikawa, 2003.

Other references Cunningham, 1996; Hepper, 1968c; Kalanda, Ataholo & Ilumbe, 1995; Ley, 2008; Muhwezi, Cunningham & Bukenya-Ziraba, 2009; Neuwinger, 2000; Tanno, 1981; Terashima, Kalala & Malasi, 1991; Waliszewski et al., 2005; Wieckhorst, 2002.

Authors M. Brink

BOEHMERIA NIVEA (L.) Gaudich.

Protologue Voy. Uranie, Bot.: 499 (1830).

Family Urticaceae

Chromosome number $2n = 24, 28, 42, 56$

Synonyms *Boehmeria tenacissima* Gaudich. (1830).

Vernacular names Ramie, rhea, China grass (En). Ramie, ramie de Chine (Fr). Rami, urtiga branca (Po).

Origin and geographic distribution Ramie probably originated in western and central China and has been cultivated in China since antiquity. Cultivation spread from China to other Asian countries. Ramie plants and products were brought to Europe in the 18th Century and experimental plantings were established in many tropical, subtropical and temperate countries. With the advent of synthetic fibres, however, the cultivation of ramie plummeted, though it is still grown in many tropical and subtropical countries. In tropical Africa small-scale cultivation has taken place in Sierra Leone, Cameroon, Equatorial Guinea, Gabon, DR Congo, Kenya, Uganda, Tanzania, Mozambique, Madagascar and the Mascarene Islands but it has not become successful and its present distribution in tropical Africa is unclear. Ramie has occasionally escaped from cultivation and naturalised.

Uses Fibre from the stem of ramie is one of the oldest textile fibres, used since prehistoric times, especially in China, India and Indonesia. In China it has also been used for paper making for many centuries. The fibre can be spun and the cloth ('grass cloth', 'grass linen' or 'Chinese linen') is used for clothing, tablecloths, napkins, sheets, pillow cases, towels, handkerchiefs, mats, sails, etc. Ramie fibre is processed into a range of other products, including canvas, mosquito nets, fire-hoses, upholstery, filter cloths, gas mantles, shoe laces, marine packings and carpet backing. Ramie is often blended with polyester, wool, silk or cotton. In Brazil undegummed ramie serves as a substitute for jute, for instance in the production of sacks. Residues remaining after fibre extraction, and also the short fibres, are used for the production of high-quality paper, such as banknotes and cigarette paper. Processing waste is also blended with cotton or rayon and made into lower-grade fabrics. Ramie fibre serves locally for the production of ropes, strings, fishing lines and nets, sewing thread and fabrics.

Ramie plants may be fed to cattle, sheep, goats, pigs, rabbits and chickens. The main parts used as fodder are the leaves and stem tops. Ramie may also be grown specifically for forage, in which case it is harvested before the fibres have fully developed. It can be given fresh, dried as a hay, ensiled with molasses or as a dried meal. The leaves and tops are also applied as green manure. In Vietnam ramie leaves are utilized in the preparation of a cake which is considered a delicacy.

In traditional medicine in DR Congo the whole plant is crushed and soaked in water to obtain a maceration which is rubbed on the body for the treatment of rheumatism, leprosy, skin diseases and wounds, instilled into the eyes to treat eye affections, instilled into the nose against rhinitis, and drunk for the treatment of diarrhoea and helminthiasis. In Malaysia ramie leaves are used to poultice boils and against flatulence; a decoction of roots and leaves is taken as a tonic in the case of dysentery and the root is applied on ulcers. In Indo-China the roots and leaves are considered to be cooling, diuretic, emollient and resolvent, and are prescribed in a number of disorders including dysuria, urogenital inflammation and prolapse of the uterus. In China and Taiwan the plant is used for diuretic, antipyretic and hepatoprotective purposes.

Production and international trade According to FAO estimates the world ramie fibre production in the period 2004–2008 was about 277,000 t per year, cultivated on about 132,000 ha, with more than 98% produced in China (272,000 t from 129,000 ha). In this period Laos produced 2100 t per year, the Philippines 1600 t and Brazil 1100 t. Most of the ramie produced is used in the producing countries and only a small proportion enters international trade (on average about 1100 t per year for the period 2004–2008). The main exporters in this period were China (about 900 t per year), the Philippines (70 t/year) and Indonesia (50 t/year). The major importer is Japan (800 t per year in 2004–2008). The highest quality ramie available on the world market is produced in the Philippines, mainly because of the superior processing equipment employed. Small quantities of undegummed ribbon were exported from Kenya to the United Kingdom just after the Second World War.

Properties The ramie fibre strands of commerce are single cells (5–)40–250(–620) mm long and (10–)25–60(–126) µm wide. They are flattened in cross-section, irregular in shape, have thick walls and a well-defined lumen, and taper to rounded ends. The fibre walls show pronounced longitudinal striations. The fibre contains 69–91% α-cellulose, 5–13% hemicelluloses, 1% lignin, 2% pectin and 2–4% ash. Fibres extracted from ramie stems by decortication contain a high amount of gums, so special methods must be used to separate them. The gums are mainly composed of hemicelluloses and pectin, which are relatively insoluble in water but fairly soluble in alkaline solutions. Properly degummed fibre contains 96–98% α-cellulose.

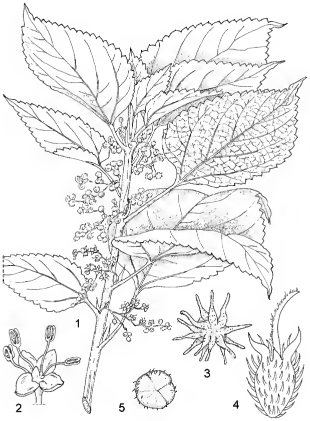
Ramie fibre is white, lustrous, strong and durable. The tensile strength, absorbency, drying properties and dyeing qualities of ramie fibre are often indicated as superior to those of cotton and flax fibre, but measured values vary widely and with respect to these characteristics ramie is rather similar to cotton and flax. However, wetting does cause less shrinkage in ramie than in other fibres, and a mixture of wool and ramie shrinks much less than pure wool. On the other hand ramie lacks the elasticity of wool and silk and the flexibility of cotton, which makes ramie cloth rather harsh, with a tendency to crease and to crack and break when bent. The tensile strength, elongation at break, and Young's modulus of ramie fibre are 400–1270 N/mm^2, 3.6–4.2% and 23,000–128,000 N/mm^2, respectively. Its resistance to bacterial action and its increased strength when wetted make ramie fibre particularly suitable for marine applications.

The nutritional value of ramie as fodder is high. Per 100 g dry matter the whole aboveground plant contains: crude protein 11–28 g, crude fibre 9–29 g, ash 15–17 g, Ca 3.7–4.5 g and P 0.13–0.31 g. The leaves contain about 25 g protein per 100 g dry matter, whereas total plant residues after fibre extraction contain about 13 g. Meal made of ramie leaves and tops contains 21–22% crude protein.

Aqueous root extracts showed in-vivo hepatoprotective and anti-inflammatory activity in rats, in-vitro anti-oxidant effects in rat liver homogenate, and free radical scavenging activity. Ethanol root extracts showed in-vitro and in-vivo activity against hepatitis B virus. Methanol root extracts showed in-vivo antidiabetic, antihyperlipidaemic and antioxidant effects in rats. An aqueous leaf extract showed antimicrobial properties against the fungus *Acremonium kiliense* and the bacteria *Bacillus cereus* and *Bacillus subtilis*, but was not effective against the fungi *Alternaria brassicicola*, *Fusarium udum*, *Macrophomina phaseolina* and *Phytophthora parasitica*. Ethylacetate leaf extracts showed free radical scavenging activity, inhibitory effects on angiotensin I-converting enzyme, and in-vitro anticancer activity.

Adulterations and substitutes Because of its high price ramie may be adulterated with other fibres, e.g. flax (*Linum usitatissimum* L.) or cotton (*Gossypium* spp.).

Description Monoecious, perennial, erect herb or small shrub 0.5–2(–3) m tall, with long rhizome and tuberous storage roots; stem usually unbranched and hollow, 8–16 mm in diameter, initially green and hairy, turning brown-



Boehmeria nivea – 1, flowering and fruiting stem; 2, male flower; 3, female flower cluster; 4, female flower; 5, fruit.
Source: PROSEA

ish and woody. Leaves alternate, simple; stipules intrapetiolar, connate at base, linear-lanceolate, up to 1.5 cm long; petiole 2.5–12 cm long, pubescent; blade broadly ovate, triangular to suborbicular, 5–20 cm × 3.5–18 cm, base cuneate to subcordate, apex usually abruptly long-acuminate, margin coarsely dentate to dentate-serrate or crenate, upper surface green and scabrid, lower surface glabrous and green or white appressed-pubescent, basal veins 3. Inflorescence axillary, racemose, paniculate, 3–8 cm long, each branch bearing several crowded or well-separated flower clusters, mainly female with a few male branches towards base; male clusters small, usually with 3–10 flowers, female clusters larger, usually with 10–30 flowers. Flowers unisexual; male flower shortly pedicelled, perianth 3–5-lobed, stamens as many as lobes and incurved with persistent rudiment of pistillode; female flower sessile, perianth tubular, 2–4-lobed, greenish to pinkish, pistil with 1-celled ovary with 1 ovule, style exserted, slender and hairy on one side, stigma filiform. Fruit a subglobose to ovoid achene c. 1 mm in diameter, enclosed by the persistent perianth, hairy, crustaceous, brown-yellow. Seed subglobose to ovoid, slightly less than 1 mm in diameter, dark brown.

Other botanical information *Boehmeria* comprises about 65 species, distributed mainly in tropical and subtropical regions, rarely in temperate regions. Considerable variation exists within *Boehmeria nivea* and usually two varieties are distinguished, although these have also been described as different species, subspecies or forms:

- var. *nivea* ('White ramie', 'Chinese ramie' or 'China grass') originates from China and Japan, and is characterized by a thick, white felt of hairs on the lower surface of the leaves. It appears better suited to temperate and subtropical climates. This taxon is cultivated on a commercial scale.
- var. *tenacissima* (Roxb.) Miq. ('Green ramie' or 'Indian ramie'; synonym: *Boehmeria tenacissima* Gaudich.) is believed to originate from Malaysia, and has smaller leaves which are green on both sides. It appears better suited to tropical climates. Green ramie might be a derivative of a cross between white ramie and an unknown species.

Growth and development Ramie is grown as a perennial crop. The rhizome starts to grow 5–20 days after planting. The storage roots are produced in early stages of growth. Harvesting may start 3–10 months after planting out the rhizomes, but the first harvest of a new plantation is often not used for fibre because of uneven growth and low fibre quality. Ramie is cross-pollinated. The male flowers open first and pollination is by wind.

Ecology Ramie is grown at average temperatures ranging from 20°C during the cropping season in temperate regions to 28°C in the tropics. Frost may destroy the rhizomes; this can be prevented by mulching with leaves or compost. To grow properly, ramie requires a minimum of 100–140 mm rainfall per month. Short days promote flowering and ramie tolerates partial shade. For optimal fibre production ramie requires rich, well-drained, sandy loams, with a pH of 5.5–6.5. With heavy manuring it can also be grown on less favourable soil types. Ramie is extremely sensitive to waterlogging.

Propagation and planting Ramie can be propagated by seed, but the resulting plants take 1–2 years to become productive and are often inferior to their parents. Therefore, ramie is usually propagated vegetatively by means of rhizome cuttings 15–-30 cm long, taken from plants at least 3 years old. To ensure optimal growth, the rhizomes should be planted out as soon as possible after being cut. If immediate planting is impossible, they should be kept moist and covered and in a shaded place. The rhizome cuttings are usually planted manually in a well-prepared seed-bed at a depth of 5–7.5 cm. Planting distances vary widely, depending on soil fertility, cultivar and availability of planting material. The spacing between rows is 25–140 cm and that within the row 5–60 cm. Ramie can also be propagated by division, air layering and stem cuttings. In-vitro propagation is possible, as complete plants have been regenerated from callus produced from ramie cotyledons, leaves, stem segments, leaf segments and hypocotyls.

Management Ramie needs regular weeding until the canopy is closed. Weeding of ratoon crops usually starts during the harvest of the preceding crop, when not only the ramie but also the weeds are cut. Because of its high productivity ramie rapidly depletes soil nutrients. Fertilization with manure or inorganic fertilizer, especially with nitrogen, is important for satisfactory yields. Leaving or returning leaves and other residues on or to the field is beneficial, because these materials contain a large proportion of the nutrients removed. The production of 45 t fresh plant material (1.5 t fibre) on a peat soil in Florida (United States) resulted in the removal of about 206 kg N, 19 kg P, 100 kg K, 230 kg Ca and 52 kg Mg. A general recommendation in the Philippines is to fertilize a plantation of 50,000 plants/ha with 90 kg N, 26 kg P and 50 kg K per harvest per ha on sandy or clay loams and with 60 kg N, 13 kg P and 25 kg K on soils rich in organic matter, and to return all plant waste to the field after fibre extraction. In some countries, replanting is done every 7 years whereas in parts of China the crop is maintained as long as 20 years.

Diseases and pests No information is available on the diseases and pests affecting ramie in tropical Africa. The most serious disease of ramie in Asia is 'white fungus disease' caused by *Rosellinia necatrix*. Other diseases known to attack ramie include angular leaf spot caused by *Pseudocercospora boehmeriae*, stem rots caused by *Corticium rolfsii* (synonym: *Sclerotium rolfsii*), *Macrophomina phaseolina*, *Phoma boehmeriae* and *Rhizoctonia solani*, and leaf spots caused by *Cercospora* spp. Many insects feed on ramie leaves, but there are few serious pests. The most widespread are leaf rollers (*Sylepta* spp.), found in almost every country where ramie is grown.

The root-knot nematode *Meloidogyne incognita* occurs regularly in ramie. It can be detected by the presence of galls on the roots. Severely infected plants are stunted and have yellow leaves. Other nematodes harming ramie include the lesion nematode (*Pratylenchus* sp.), stunt nematode (*Tylenchorhynchus* sp.) and reniform nematode (*Rotylenchulus* sp.).

Harvesting The timing of the harvest of ramie is crucial: if stems are immature, the fibre yield is reduced; if stems are too mature, it is difficult to remove the fibre. Harvesting is usually carried out when the stems start turning brown and growth slows down. In temperate regions ratoon crops can be harvested 2–3 times a year, in subtropical areas 4–5 times, and in tropical areas up to 7 harvests a year are possible. However, the yield per harvest is usually higher in temperate regions, and it is possible that more fibre is obtained per ha per year from 2–3 harvests in temperate regions than from more harvests in tropical areas. The plants are usually harvested manually with a sickle close to the ground to prevent new stalks arising from the old stump. In some areas the stems are bent over to break the core and the cortex is stripped from plants in the field. Mechanical harvesters have been developed but are not used commercially. At harvesting, the tops and the leaves may be removed from the stems and used as animal feed or green manure.

Yield The fresh stem yield of ramie is normally 45–60 t per ha per year, giving about 2000 kg dried fibre and 1500 kg degummed fibre. For the Philippines yields have been recorded of 2000 kg dried fibre per ha in the first year after planting and 3500 kg in subsequent years. Yields start to decline when plantings become overcrowded; at this point the rhizomes may be pruned, e.g. by ploughing, or the area may be replanted.

When grown for fodder, the yield may amount to 300 t fresh material or 42 t dry matter per ha per year in up to 14 cuts.

Handling after harvest Ramie is processed into fibre in one or two steps: the first being extraction, the second being degumming. Extraction is usually done manually by defoliating the stems and removing the entire raw bast ribbon, which is then scraped to remove the outer bark, non-fibrous parenchyma and much of the gummy material. Manual extraction is very labour intensive, and in Brazil, Japan and parts of the Philippines ramie is decorticated mechanically using machines based on the same principles as those used for kenaf (*Hibiscus cannabinus* L.) or sisal (*Agave sisalana* Perrine). Ramie fibre cannot be extracted satisfactorily by retting, because of the presence and nature of large amounts of gums in the bark, though some bacteria have been found to decompose the gums. The fibres are extracted when the stems are still fresh, because the bark is more difficult to remove when the plant dries. If extraction cannot be done immediately after harvesting, the stems are kept in water to keep them fresh. Extracted fibres are hung over poles for 1–3 days to dry and bleach in the wind and sun. Drying is done as soon as possible, to prevent attack by fungi and bacteria. After being dried, the fibres may be brushed to reduce the gum content. Undegummed ramie fibre may be used for coarse ropes for marine applications, sacks and other containers and rugs and carpets. There are no universally accepted grades, and each country has its own way of grading.

Degumming is necessary to remove the gums contained in the raw ramie fibre. The presence of gums makes the fibre stiff and brittle, and they must be removed before the fibre can be combed and spun into fine yarns. In areas where processing is manual, this may be done by repeated soaking, scraping, washing and sun-drying. Other methods include treatment with soap solution, lime or chemicals. Many chemical degumming methods have been developed, but they are usually kept secret by the textile mills using them. Usually they contain the same basic steps: boiling in an aqueous alkaline solution; washing with water; bleaching with an oxidizing agent; washing with water; and oiling with a sulphonated hydrocarbon. If carried out incorrectly, degumming can reduce the strength of ramie fibre and increase its brittleness. The chemical degumming process produces polluting effluents. Combined microbial and chemical degumming processes have been proposed to reduce the use of chemicals and energy, and to improve the resulting fibre quality, but they have not yet been applied on industrial scale.

In industrialized regions, ramie is commonly spun on machinery developed for silk, wool or cotton. The results are often less satisfactory, however. When a short-fibre spinning system like the one used for cotton is used, ramie fibre has to be cut short ('stapling').

Genetic resources The Institute of Bast Fiber Crops of the Chinese Academy of Agricultural Sciences (CAAS) in Yuanjiang, China, has a collection of about 1300 ramie accessions, and characterizes and evaluates botanical and agronomical characters, fibre yield, quality and stress resistance. More than 1000 accessions have been planted in the field in Yuanjiang to create the 'National Ramie Germplasm Field Genebank'. Germplasm collections are also available at the Instituto Agronômico de Campinas (IAC), São Paulo, Brazil and the Institute of Plant Breeding of the University of the Philippines Los Baños.

Breeding Ramie is a clonal crop, so the breeding methods applied are similar to sugar cane or potato. Seedlings are mostly very inferior in quality and to obtain improved cultivars initial recombination crossing has to be followed by a long programme of clonal selection. Selection work on ramie has been carried out in various countries, including the Philippines and Indonesia. In China, the Institute of Bast Fibre Crops has selected and distributed more than 30 elite accessions. In India 5 cultivars were selected on the basis of yield, gum content, fertilizer response and resistance to stress, and the most popular of these ('R 67–34') has been released. Important considerations in ramie selection are: adaptation to ecological conditions, decortication characteristics, leafing and branching characteristics, resistance to diseases and pests, tendency to lodge and fibre characteristics (uniformity, strength, fineness and colour).

In Brazil a protocol has been developed for the genetic modification of ramie and experiments are being carried out to improve the amino acid composition and thus the fodder value of ramie through genetic modification. In China genetic transformation of ramie plants has been achieved by *Agrobacterium*-mediated methods.

Prospects Because of the difficulties and costs involved in the production and processing of ramie, it is unlikely that the crop will become a major trade commodity and challenge the established major natural and synthetic fibres. However, the excellent properties of its fibre and the wide range of possible uses make ramie a promising cash crop for the local market in many tropical and subtropical countries. The development of new technologies such as decorticating and stripping machines and degumming processes suitable for medium- and small-scale operations, may improve the chances of ramie becoming more important as a fibre crop. The medicinal properties of *Boehmeria nivea* seem to justify more research.

Major references Burkill, 2000; Chang et al., 2010; Chen et al., 2003; Chifundera, 2001; Dempsey, 1975; Escobin, 2003; Jarman, 1998; Kirby, 1963; Kozlowski, Rawluk & Barriga-Bedoya, 2005; Mwaikambo, 2006.

Other references Bandopadhyay, Ghosh & Das, 2003; Chen et al., 2005; FAO, 2011; Friis, 1989c; Greenway, 1950; Hauman, 1948b; Huang et al., 2006; Keay, 1958i; Leandri, 1965; Letouzey, 1968; Lin et al., 1997; Lin et al., 1998; Marais & Jellis, 1985; Munawar, Umemura & Kawai, 2007; Nho et al., 2010; Raponda-Walker & Sillans, 1961; Sancheti et al., 2011; Wang et al., 2007; Xiongfeng Ma et al., 2010.

Sources of illustration Escobin, 2003.

Authors M. Brink

Based on PROSEA 17: Fibre plants.

BOLBOSCHOENUS MARITIMUS (L.) Palla

Protologue Syn. Deut. Schweiz. Fl., ed. 3, 3: 2531 (1904).

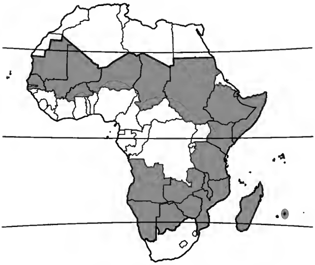
Family Cyperaceae

Chromosome number *n* = 49, 52, 54, 55, 2*n* = 96, 104, 110.

Synonyms *Scirpus maritimus* L. (1753), *Schoenoplectus maritimus* (L.) Lye (1971).

Vernacular names Sea club-rush, saltmarsh club-rush, saltmarsh bulrush, alkali bulrush, cosmopolitan bulrush, bayonet grass (En). Scirpe maritime, souchet maritime (Fr). Junco da praia (Po).

Origin and geographic distribution *Bolboschoenus maritimus* is widely distributed in the tropical, subtropical and temperate regions of the world. It served as food in prehistoric times already and has been found in excavations dating from before 5000 BC.



Bolboschoenus maritimus – wild

Uses In Ethiopia the stems are used for thatching. In Somalia they are used in locust bait. In India the seeds are eaten raw or they are pounded, made into flour and mixed with millet. The rhizome is edible as well. In traditional medicine in Korea the tuber is used for the treatment of tumours and vaginal indurations. *Bolboschoenus maritimus* is planted as an ornamental in or near ponds. It can be used in the creation and rehabilitation of wetlands. It helps to control erosion by its roots stabilizing soil and the whole plant providing protection against wind and waves.

Properties The fruit contains 6% protein and 2.4% oil. An ethanolic extract of the seed has shown in-vivo activity against P-388 lymphocytic leukaemia in mice. The most active compound was piceatannol, which is also known to have antifungal and ichthyotoxic properties. The extract also contained viniferin, known to have antifungal properties, and resveratrol, known to have antiplatelet aggregation, coronary vasodilator, antileukaemic, antifungal and protein-tyrosine kinase inhibitory activities. The aerial parts contain an alkaloid.

Botany Perennial, spreading herb with long, hard stolons or rhizomes ending in tubers or stems; stems up to 150 cm tall, 1–10 mm in diameter, sharply 3-angled, filled with pith or hollow, lower half covered with leaf sheaths. Leaves in 3 vertical ranks; sheath with 4 mm long v-shaped opening (throat), pale green; ligule absent; blade linear, flat, 10–40(–50) cm × 2–10 mm, acuminate at the apex, glabrous or with scabrid margins and midvein. Inflorescence a terminal anthela with clusters of spikelets on branches of unequal length, main branches usually 0.5–3 cm long, secondary branches rare, total number of spikelets up to 50; involucral bracts many, largest ones leaf-like, 8–18 cm long, erect or spreading. Spikelets sessile, ovoid, ellipsoid or almost cylindrical, 5–50 mm × 2–10 mm, often somewhat curved, golden brown to dark brown, many-flowered; glumes imbricate, ovate or elliptical, 3–8 mm long, toothed or emarginate at the apex, margin and surface with minute hairs, 1–3-veined; flowers bisexual, perianth of 3–6 needle-like bristles, stamens 3, anthers 3–4 mm long, ovary superior, 1-locular, stigmas (2–)3. Fruit an obovate nutlet 1–3 mm × 1.5–2.5 mm, 3-angled, without raised papillae, almost smooth, shiny, from grey-green to dark brown to black, 1-seeded.

Bolboschoenus comprises 6–16 species, widely distributed in tropical, subtropical and temperate regions. It is sometimes considered a subgenus of *Scirpus* or *Schoenoplectus*. Species delimitation in the genus is rather confused, and the genus is in need of revision.

In Senegal *Bolboschoenus maritimus* flowers in (July–)August–October(–November). The fruits are dispersed by water currents and birds. *Bolboschoenus maritimus* follows the C_4-cycle photosynthetic pathway.

Ecology *Bolboschoenus maritimus* occurs from sea-level up to 1800 m altitude in saline pools and marshes and seasonally wet, saline grassland. It can also grow under non-saline conditions. The plant tolerates almost total submersion in water and the rhizome survives dry periods by remaining dormant. *Bolboschoenus maritimus* is an important weed in agricultural fields and waterways, often occurring in wet rice fields. In Australia its import is prohibited.

Management Plants can be propagated with seeds or by rhizome division. The 1000-seed weight is 1.2–3.3 g. Germination is optimal at day-time temperatures of 25–35°C and night-time temperatures of about 5°C lower. Germination takes 1–2 weeks. Planted rhizome pieces usually sprout in about 5 days.

As a weed in rice-producing areas of Asia *Bolboschoenus maritimus* is controlled with integrated weed management schemes, including rotation of crops, application of water regimes, and chemical and cultural methods.

Genetic resources and breeding As *Bolboschoenus maritimus* is distributed worldwide and common, also as a weed in cultivated land, it is not threatened with genetic erosion.

Prospects *Bolboschoenus maritimus* is a very widely distributed plant, which, however, is only occasionally used in tropical Africa. Care should be taken in planting this species, because it is an important weed in rice and other crops.

Major references Burkill, 1985; Goetghebeur & Simpson, 1991; Lye, 1997a; Simpson & Inglis, 2001; Vanden Berghen, 1988.

Other references Barclay & Earle, 1974; Browning & Gordon-Gray, 1992; Bryson & Carter, 2008; Fletcher, 2004; Graham et al., 2000; Hoenselaar, Verdcourt & Beentje, 2010; Jarolímová & Hroudová, 1998; Okeyo, 2006; Powell, Bajaj & McLaughlin, 1987; Rodenburg & Johnson, 2009; Wilman, 2003.

Authors M. Brink

BOMBAX BUONOPOZENSE P.Beauv.

Protologue Fl. Owar. 2: 42. t. 83 (1816).

Family Bombacaceae (APG: Malvaceae)

Chromosome number $2n$ = c. 96

Synonyms *Bombax reflexum* Sprague (1906), *Bombax flammeum* Ulbr. (1913).

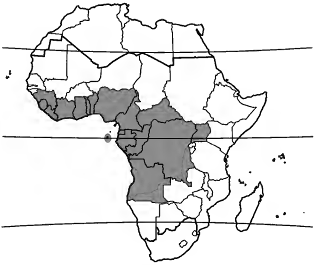
Vernacular names Gold Coast bombax, West African bombax, wild kapok, red silk cotton tree, wild silk cotton tree (En). Kapokier de Buonopozo, fromager de Buonopozo (Fr). Mafumeira africana, mafumeira encarnada, poilão encarnado, poilão ferro (Po).

Origin and geographic distribution *Bombax buonopozense* is distributed from Guinea eastward to Uganda and southward to Angola.

Uses The seed-floss is used for stuffing mattresses and cushions. Sheets of bark have been used as roofing material for small huts.

The wood is used for making dug-out canoes, troughs, quivers, stools and domestic appliances. It is also suitable for light construction, light flooring, interior trim, sporting goods, agricultural implements, boxes, modelling, carvings, toys, turnery, insulation, woodwool, plywood, hardboard and particle board. The spines have been carved into pieces for the game of checkers or other small objects, such as letters, used for embossing. A reddish-brown dye has been obtained from the bark. The bark also yields a gum-exudate.

The young fruits, flowers and fresh or dried leaves are eaten as vegetables and in sauces. The dried calyx mixed with bark or spines was formerly chewed as a substitute of kola nut or to clean teeth. In Sierra Leone the young fruits with the calyx attached are used as tops. The seeds yield an edible oil. The fresh leaves are a



Bombax buonopozense – wild

fodder for goats. The flowers are an important source of food for honeybees. *Bombax buonopozense* is occasionally planted as an ornamental avenue tree.

The bark, flowers and leaves have emollient properties and in traditional medicine in Côte d'Ivoire the bark is pulped and made into plasters to treat ringworm and to clean hairy leather. The powdered bark with spines enters into medicines for the treatment of various skin diseases and river blindness. In Ghana a decoction of the stem bark is drunk against malaria, while in Sierra Leone an infusion in cold water is rubbed on the head or drunk against dizziness. The bark also enters into preparations applied to treat cardiac and menstrual problems, and as a galactagogue. The stem bark has been used in Nupeland in north-central Nigeria to treat sleeping sickness. Bark decoctions are drunk or used in a bath against fever.

Production and international trade The fruit floss was formerly exported from West Africa to Europe as a substitute of kapok from *Ceiba pentandra* (L.) Gaertn. Before the Second World War about 1000 t of fibre from *Bombax* spp. were exported annually. Nowadays it is only used and traded locally. The flowers, leaves and wood are also only used locally.

Properties *Bombax* fibre cannot be spun and for most purposes kapok fibre from *Ceiba pentandra* is superior to that of *Bombax* species.

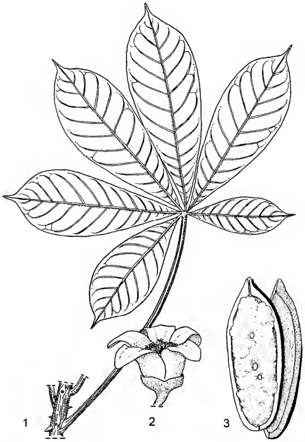
The heartwood is yellowish brown to pinkish brown, darkening on exposure; it is not clearly demarcated from the greyish white sapwood. The grain is straight or interlocked; texture coarse. The wood is lightweight and soft, but strong. It dries quickly, but is subject to warping if not dried properly. The wood is easy to work with machine and hand tools, but sharp-edged tools must be used to avoid woolly surfaces. Sanding and scraping must be done carefully. The wood nails well, but holding properties are poor. It glues and finishes well. The wood is not durable and easily attacked by insects and fungi. The sapwood is permeable to impregnation with preservatives, the heartwood is moderately resistant.

Per 100 g edible portion the raw leaves contain: water 80.0 g, energy 260 kJ (62 kcal), protein 3.4 g, fat 0.6 g, total carbohydrate (including fibre) 14.5 g, fibre 3.5 g, Ca 276 mg, P 32 mg. The raw calyces contain per 100 g edible portion: water 82.0 g, energy 268 kJ (64 kcal), protein 1.2 g, fat 0.8 g, total carbohydrate (including fibre) 14.8 g, fibre 2.4 g, Ca 174 mg, P 27 mg. The dried calyces contain per 100 g edible portion: water 10.9 g, energy 1306 kJ (312 kcal), protein 3.2 g, fat 3.8 g, total carbohydrate (including fibre) 76.3 g, Ca 741 mg. The dried seeds contain per 100 g edible portion: water 6.0 g, energy 1947 kJ (465 kcal), protein 19.3 g, fat 27.5 g, total carbohydrate (including fibre) 41.3 g, fibre 12.2 g, Ca 348 mg, P 676 mg (Leung, Busson & Jardin, 1968).

Methanol extracts of the stem-bark have shown in-vivo antitrypanosomal activity in mice. The treatment removed the parasites from the bloodstream in 7 days. Methanol extracts of the leaves have shown antinociceptive, anti-inflammatory and antipyretic effects in rats and mice. Methanolic and to a lesser extent hexane extracts of the flowers showed antibiotic activity against *Aspergillus niger*, *Escherichia coli* and *Staphylococcus aureus*.

Adulterations and substitutes *Bombax costatum* Pellegr. & Vuillet is used for similar purposes as *Bombax buonopozense*. The fruit floss of the true kapok tree, *Ceiba pentandra*, is superior to that of *Bombax buonopozense* and other *Bombax* species.

Description Large tree up to 40 m tall; bole straight, cylindrical, branchless for 18–24 m, up to 75(–150) cm in diameter, with wing-shaped buttresses up to 6 m high; outer bark corky, greyish brown, with conical spines up to 3 cm long, inner bark dark pink; branches in whorls, glabrous. Leaves palmately compound with 5–9 leaflets; stipules narrowly lanceolate, soon falling; petiole 22–24 cm long, petiolules absent or up to 2 cm long; leaflets oblong-obovate, 6–23 cm × 3–7.5 cm, apex long acuminate, both surfaces glabrous or lower surface puberulous, midvein prominent on both surfaces, lateral veins in 10–25 pairs, slightly prominent. Flowers solitary or 2–6 together in small axillary cymes on short branches; pedicel up to 2.5 cm long; calyx cup-shaped, 1–1.5 cm × 2.5–4.5 cm, 5-lobed; petals 5, oblong to oblong-lanceolate, 5.5–9.5 cm × 2.5–3.5 cm, red; staminal tube 7–8 mm long, stamens c. 180, in outer circle in 5 bundles of c. 30, in inner circle in 5 pairs; ovary superior, conical, 5.5–8 mm long, 5-ribbed, style 4–5 cm long, stigma 5-lobed. Fruit an oblong capsule 8–20 cm × 3.5–8 cm, 5-ridged to 5-angular, glabrous, dark brown to black, loculicidal, many seeded. Seeds pear-shaped, 5–8 mm in diameter, brown, embedded in abundant, white, silky floss. Seedling with epigeal germination; hypocotyl c. 6.5 cm long;



Bombax buonopozense – 1, part of branch with leaf; 2, flower; 3, opened fruit.
Redrawn and adapted by H. de Vries

cotyledons ovate-cordate; first leaves 3-foliolate.

Other botanical information *Bombax* is a pantropical genus comprising 8 species: 2 in Africa, 5 in Asia, and 1 from Asia to the Solomon Islands. Formerly, *Bombax* had a much wider circumscription. Reports of *Bombax buonopozense* in Mozambique mostly refer to *Rhodognaphalon schumannianum* A.Robyns.

Anatomy Wood-anatomical description (IAWA hardwood codes):

Growth rings: 2: growth ring boundaries indistinct or absent. Vessels: 5: wood diffuse-porous; 13: simple perforation plates; 22: intervessel pits alternate; 23: shape of alternate pits polygonal; 26: intervessel pits medium (7–10 μm); 27: intervessel pits large (≥ 10 μm); 31: vessel-ray pits with much reduced borders to apparently simple: pits rounded or angular; 32: vessel-ray pits with much reduced borders to apparently simple: pits horizontal (scalariform, gash-like) to vertical (palisade); 43: mean tangential diameter of vessel lumina ≥ 200 μm; 46: ≤ 5 vessels per square millimetre; (47: 5–20 vessels per square millimetre). Tracheids and fibres: 61: fibres with simple to minutely bordered pits; 66: non-septate fibres present; 69: fibres thin- to thick-walled. Axial parenchyma: 77: axial parenchyma diffuse-in-aggregates; 79: axial parenchyma vasicentric; 86: axial parenchyma in narrow bands or lines up to three cells wide; (88: axial parenchyma scalariform); 92: four (3–4) cells per parenchyma strand; 93: eight (5–8) cells per parenchyma strand. Rays: 98: larger rays commonly 4- to 10-seriate; (102: ray height > 1 mm); 104: all ray cells procumbent; 106: body ray cells procumbent with one row of upright and/or square marginal cells; 107: body ray cells procumbent with mostly 2–4 rows of upright and/or square marginal cells; 110: sheath cells present; 114: ≤ 4 rays per mm; 115: 4–12 rays per mm. Storied structure: 120: axial parenchyma and/or vessel elements storied. Secretory elements and cambial variants: 131: intercellular canals of traumatic origin. Mineral inclusions: 136: prismatic crystals present; 137: prismatic crystals in upright and/or square ray cells; 141: prismatic crystals in non-chambered axial parenchyma cells.
(P. Mugabi, A.A. Oteng-Amoako & P. Baas)

Growth and development Seedlings grow rapidly, up to 3 m in the first 2 years. In Ghana *Bombax buonopozense* loses its leaves during the dry season from December to March. It flowers during the dry season, mainly in December and January, and fruits mature in (February–)March–May(–June). In Central Africa flowering is probably year-round. Fruiting begins when trees are 6–7 years old. Fruits open into 5 segments, often when still on the tree and the seeds are dispersed by wind.

Ecology *Bombax buonopozense* occurs throughout the dense forests of the upper and lower Guinean zone, typically at low elevations, but is reported from elevations up to 1200 m above sea-level. It occurs in primary rainforest, secondary forest, gallery forest and swamp forest, extending into, but much rarer, in wooded savanna, coastal thicket and grasslands, for instance in Ghana. In the Sudanian and Sahelian zones of West Africa it is replaced by *Bombax costatum*.

Propagation and planting Direct sowing and transplanting of potted seedlings are possible. Before sowing, the kapok adhering to the seed should be removed. The 1000-seed weight is about 70 g. Seed can be stored in a cool and dry place. Germination normally takes 8–12 days in West Africa. Propagation with cuttings is also possible.

Management Although it has been proposed in the past to test *Bombax buonopozense* for the commercial production of kapok, it mainly grows wild, except for occasional planting as an avenue tree. It is suitable as an agroforestry tree, for instance for staking yams.

Diseases and pests *Bombax buonopozense* is an alternative host of cacao swollen shoot virus (CSSV).

Genetic resources As the species is widespread, common and not heavily exploited, *Bombax buonopozense* is not in danger of genetic erosion.

Prospects *Bombax buonopozense* is likely to remain a fibre, food, timber and medicinal tree of local importance. Very little information is available on the properties of the fibre.

Major references Beentje, 1989; Beentje & Smith, 2001; Burkill, 1985; Burkill, 2000; Irvine, 1961; Katende, Birnie & Tengnäs, 1995; Neuwinger, 2000; Robyns, 1963a; Robyns, 1963b; Villiers, 1973.

Other references Abdullahi, Buhari Salawu & Abdulrauf, 2011; Akuodor et al., 2011; Anonymous, 1958; Asase & Oppong-Mensah, 2009; Baum & Ogunima, 1994; Bolza & Keating, 1972; de la Mensbruge, 1966; InsideWood, undated; Keay, 1958a; Leung, Busson & Jardin, 1968; Mann et al., 2011; Nnamani & Agwu, 2007; Oteng-Amoako (Editor), 2006; Owusu-Sekyere, 1999; Raponda-Walker & Sillans, 1961; Robyns, 1957; Villiers, 1975.

Sources of illustration Hawthorne & Jongkind, 2006.

Authors L.P.A. Oyen

BOMBAX COSTATUM Pellegr. & Vuillet

Protologue Notul. Syst. (Paris) 3: 88 (1914).

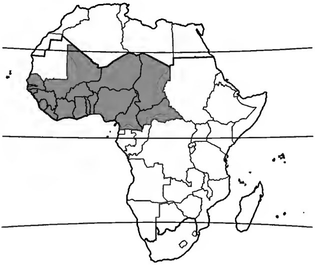
Family Bombacaceae (APG: Malvaceae)

Chromosome number $2n = 72$

Synonyms *Bombax andrieui* Pellegr. & Vuillet (1914), *Bombax houardii* Pellegr. & Vuillet (1914).

Vernacular names Red-flowered silk-cotton tree, red kapok tree, Gambia silk-cotton tree (En). Kapokier à fleurs rouges, fromager, kapokier rouge, faux kapokier, kapokier de forêt (Fr). Poilão foro, polóm fidalgo, polóm fôro, sumauma (Po).

Origin and geographic distribution *Bombax costatum* occurs from Senegal eastward to Cameroon, southern Chad and the Central African Republic.



Bombax costatum – wild

Uses The white floss present in large amounts in the fruit is widely used for stuffing mattresses, pillows and cushions. The wood has acoustic properties making it suitable for sound boxes of drums and xylophones. It is also used for making match-sticks, domestic appliances and door and window frames, and as fuelwood. Long boles are made into dug-out canoes. The bark is used for making whistles. In Sierra Leone stakes are planted to establish live fences. The bark contains tannins and yields a brown dye. In Burkina Faso the bark is used for staining the teeth red. The flowers are widely collected for the fleshy calyx which is cooked and eaten as a vegetable. The leaves too, are used as a vegetable. The unripe fruit and sometimes the flowers are added to sauces to thicken them. The young, unripe fruit is also used in the preparation of a beverage. Flowers and leaves are valuable fodder for domestic animals, while the tree provides shade for grazing animals. The seed oil is suitable for consumption. The flowers are important as bee forage.

Several parts of the tree are used in traditional medicine against a great variety of illnesses. A maceration of the powdered root is eaten in a sauce or applied as a bath against epilepsy. Bark preparations are applied to wounds to promote healing. In Senegal and Sierra Leone diuretic properties are attributed to the bark of stem and roots. The bark is also used to prepare a medicine against trichomoniasis, amoebiasis and other forms of dysentery. A bath in an extract of the stem bark is taken against insanity. The powdered stem bark enters into a medicine applied as fumigation against headache. For the treatment of headache or toothache a compress of the bark may be tied on the head. The bark is also used for the treatment of skin diseases. In Mali a decoction of the bark and leaves and parts of other plants is taken against menstrual problems. The leaves are emollient and a warm bath in a decoction of the leaves may be prescribed to feverish patients, especially children. The leaves also enter into treatments of hookworm and the flowers against taenia. In Senegal the leaves are prescribed with other drug plants for the treatment of leucorrhoea and diarrhoea. An extract of the ground leaves is drunk against problems during childbirth. A bath in an extract of the ground leaves is taken repeatedly against convulsions. A tea of dried leaves is drunk or applied to the body against measles. A decoction of the leaves and the root or stem bark is drunk in serious cases of oedema. A decoction of the leaves and young twigs is drunk for the treatment of jaundice. A decoction of the leaves is also given to children to drink against rickets. Various plant parts are used for promoting lactation and as a tonic against fatigue. Leaves mixed with shea butter are rubbed onto affected skin against leprosy.

In traditional veterinary medicine, leaves ground in water are given to sheep bitten by a snake. In Burkina Faso, a maceration of pounded leaves is given to animals with a retained placenta. In Niger a cold decoction of leaves and twigs is given to animals with piles.

Production and international trade Kapok from *Bombax costatum* and other *Bombax* spp. was formerly exported from francophone West Africa; about 1000 t of kapok were exported annually. Nowadays the fibre and other products are only used and traded locally.

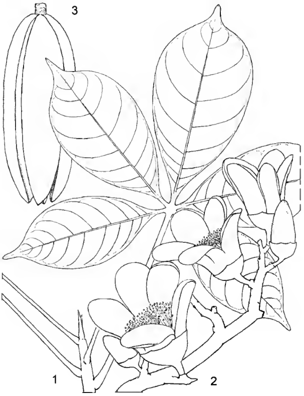
Properties Little information on the properties of the kapok of *Bombax costatum* is available. The fibre cannot be spun. For most purposes, kapok of *Ceiba pentandra* (L.) Gaertn. is considered superior.

The wood is pale yellow to whitish with an orange lustre when newly felled, but soon turns grey when exposed to sunlight. The heartwood is not clearly demarcated from the sapwood. The wood is lightweight, with a density of 380–500 kg/m^3 at 12% moisture content. It seasons well and is not liable to major warping or shrinkage. The rates of shrinkage from green to oven dry are 2.7–3.3% radial and 5.1–6.2% tangential. The wood is soft. At 12% moisture content, the modulus of rupture is 61–71 N/mm^2, modulus of elasticity 4500–5400 N/mm^2, compression parallel to grain 23–31 N/mm^2, shear 3–4 N/mm^2, cleavage 8 N/mm and Chalais-Meudon side hardness 1.0–1.3. The wood is easy to work. Untreated wood is rapidly attacked and destroyed by fungi and insects.

In Niger the fruit was found to contain 20–25% protein. The seeds have a high oil content (20%). The fatty acid composition of the oil is: caproic acid 3%, caprylic acid 7%, palmitic acid 8%, stearic acid 3%, oleic acid 49%, linoleic acid 13%, rachidic acid 3%, lignoceric acid 1–2%, and others 13%. The mucilaginous extract from the flowers is made up mainly of the sugars rhamnose and arabinose; it is a suitable adhesive for making particle board. Preliminary observations in Senegal indicate that the feed value of the leaves in ruminants is better than average with an in-vitro dry matter digestibility of 66%. The root and stem bark have shown molluscicidal activity against *Bulinus globulus*.

Adulterations and substitutes *Bombax buonopozense* P.Beauv. is used for similar purposes as *Bombax costatum*. The fruit floss of the true kapok tree, *Ceiba pentandra*, is superior to that of *Bombax costatum* and other *Bombax* species.

Description Deciduous, small tree 3–15(–30) m tall; bole straight, up to 60(–100) cm in diameter, sometimes buttressed; outer bark



Bombax costatum – 1, part of leafy branch; 2, part of flowering twig; 3, fruit.
Source: Flore analytique du Bénin

thick, rough, corky, greyish brown, covered with conical pointed spines when young, inner bark pale red-brown; crown storeyed in young trees, later irregular, spreading and sturdy; branchlets stellate hairy. Leaves palmately compound with 5–7 leaflets; stipules falling early; petiole 10–18 cm long; petiolules up to 5 mm long; leaflets obovate, 8–16 cm × 4–6 cm, base decurrent, apex long acuminate, margin entire, both surfaces glabrous, lateral veins in 8–13 pairs. Flowers solitary, bisexual, 4.5–7 cm long; pedicel 1–1.5 cm long; calyx cup-shaped, 12–17 mm long, truncate, 5-toothed; petals 5, oblong-linear, 4–6.5 cm × c. 1.5 cm, apex rounded, red to orange, rarely yellow; stamens up to 200, in bundles, up to 4 cm long; ovary conical, 5-angled, style glabrous, stigmas lobed, spreading. Fruit an ellipsoid capsule 5–16 cm × 3–6 cm, dark brown to black, 5-valved, loculicidal; valves grooved. Seeds globose to pear-shaped, 4–5 mm in diameter, dark brown to black, embedded in white floss.

Other botanical information *Bombax* is a pantropical genus, comprising 8 species: 2 in Africa, 5 in Asia, and 1 from Asia to the Solomon Islands. Formerly, *Bombax* had a much wider circumscription. *Bombax costatum* is sometimes considered conspecific with *Bombax buonopozense*.

Bombax ceiba L. (synonym: *Bombax malabaricum* DC.; English names: red silk cotton tree, cottonwood, Indian bombax; French names: bombax, fromager; Portuguese name: algodoeiro do mato) is distributed from tropical and subtropical Asia and Australia to the Solomon Islands. It is planted throughout the subtropics and tropics, including tropical Africa, where it has been grown commercially in Tanzania before the Second World War. It is also reported to have been planted in Zimbabwe. *Bombax ceiba* resembles *Bombax costatum*, but is mostly glabrous. In Asia the fruit floss is used for stuffing and insulation, the flowers and leaves as vegetables and fodder; the wood as timber; and all parts as medicine against a wide range of ailments. The seed oil is used in cooking and soap manufacture. The tree is widely planted as ornamental. In India it plays a role in the Holi festival.

Growth and development *Bombax costatum* grows fairly fast. It may grow to a height of 30 m, but in the Sahel it seldom grows taller than 6 m. It flowers after leaf-fall, between October/November and January/February, and new leaves unfold from April onwards. Under favourable conditions, trees start bearing fruit from the 6th year onwards. Fruit ripening begins in August–September. Unfortunately, trees often do not produce fruits due to fire-damage at the critical time of flowering in the dry season. Fruits mostly open while still on the tree and the lightweight seeds are spread by wind. The roots are tuberous and act as water and sugar storage organs for long drought periods.

Ecology *Bombax costatum* is a characteristic tree of the savannas and dry woodlands of the Sudanian zone of West Africa, extending to the north into the Sahelian zone and to the south in the Guinean zone. In Burkina Faso it grows in the 600–900 mm annual rainfall zone. It grows on stony and gravelly lateritic soils, and often in cropland and close to settlements. Its thick, corky bark protects it against fire. *Bombax costatum* is usually associated with *Pterocarpus erinaceus* Poir., *Daniellia oliveri* (Rolfe) Hutch. & Dalziel, *Cordyla pinnata* (Lepr. ex A.Rich.) Milne-Redh., *Terminalia macroptera* Guill. & Perr. and *Prosopis africana* (Guill. & Perr.) Taub. In the dense forests of the Guinea zone, *Bombax costatum* is replaced by *Bombax buonopozense*.

Propagation and planting *Bombax costatum* is best propagated by direct seeding, but wildlings may also be used. The 1000-seed weight is 35–60 g. Before sowing, the fibrous material covering the seed should be removed. The seed should then be scarified in boiling water and soaked in cold water for 24 hours. Seedlings are difficult to transplant in spite of their vigorous rooting ability. Natural regeneration is easy and abundant when the seedlings are sufficiently protected against fire and livestock. Vegetative propagation is possible.

Management Trees coppice well.

Yield A tree bears up to 1500 fruits, each with 5–8 g of kapok. Under favourable conditions, 3–5 kg kapok per tree can be obtained from the 10th year onwards.

Genetic resources In spite of the value attributed to *Bombax costatum* by the local population throughout West Africa, tree numbers in dry savanna and parkland, for instance in Burkina Faso, are declining. Several studies have shown that its rejuvenation in the degrading savanna parkland is inadequate to sustain production of flowers, fruits and leaves for food and fibre. Cutting of trees and burning both affect rejuvenation. Although the tree is fire-tolerant, fruits that develop during the dry season are not and several reports indicate that seed supply is inadequate to sustain the proportion of *Bombax costatum* in the parkland vegetation. While the genetic diversity of *Bombax costatum* is not yet in danger, it is under threat as an economic resource.

Prospects If *Bombax costatum* is to remain an important and widely available source of food, feed and fibre, more attention to its conservation in the West African parkland vegetation is essential. Remarkably little information is available on the properties of the fibre, on the nutritional value as a vegetable and a fodder, and on its pharmacological composition. Still less is known about its management as an agroforestry species.

Major references Achigan-Dako et al., 2010; Beentje & Smith, 2001; Burkill, 1985; Hansen, Sanou & Nacoulma, 2008; Keay, 1958a; Lykke, Mertz & Ganaba, 2002; Nikiema, 2005; Pare et al., 2010; Robyns, 1957; Villiers, 1975.

Other references Adewunmi & Sofowora, 1980; Adjanohoun et al., 1979; Adjanohoun et al., 1989; Arbonnier, 2000; Belem et al., 2008; Codjia, Assogbadjo & Ekué, 2003; Cook et al., 2000; Diallo, 1994; Eyog Matig et al. (Editors), 2006; Fall, 1991; Gijsbers, Kessler & Knevel, 1994; Inngjerdingen et al., 2004; Kristensen & Lykke, 2003; Mertz, Lykke & Reenberg, 2001; Nacro & Millogo-Rasolodimbi, 1993; Nenonene et al., 2009; Neuwinger, 2000; Onana, 1995; Orwa et al., 2009; Takahashi, 1978.

Sources of illustration Akoègninou, van der Burg & van der Maesen, 2006.

Authors L.P.A. Oyen

BRACHYSTEGIA FLORIBUNDA Benth.

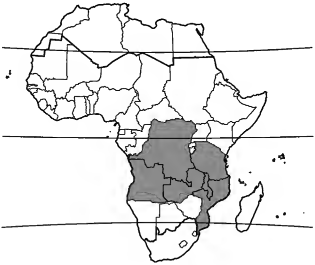
Protologue Hooker's Icon. Pl. 14: sub t. 1359 (1881).

Family Caesalpiniaceae (Leguminosae - Caesalpinioideae)

Origin and geographic distribution *Brachystegia floribunda* is distributed in DR Congo, Tanzania, Malawi, Zambia, Angola and Mozambique.

Uses The inner bark is used for lashings. The wood is used for poles, rafters, planks, tool handles and mine props. In Malawi it is used as fuelwood and for making charcoal. The tree is browsed by livestock and is a source of feed for bees and edible caterpillars. In traditional medicine in Malawi a leaf infusion is used for the treatment of eye problems.

Properties The durability of the wood is low.



Brachystegia floribunda – wild

Botany Deciduous small tree up to 13(–25) m tall; bole up to 50 cm in diameter; outer bark shallowly fissured longitudinally or coarsely reticulate, flaking in thick rectangular scales, dark grey, inner bark reddish; crown at first thin, narrow, erect-branched, finally spreading and irregularly rounded; young branches pubescent or glabrous. Leaves alternate, 7–18 cm long, pendulous, paripinnately compound with 2–5 pairs of leaflets, the pairs widely spaced; stipules intrapetiolar, free, lanceolate, 5–30 mm × 1–8 mm, early caducous, without auricles; petiole (1.5–)2–7 cm long, slender, pulvinate; rachis (2.5–)3–8(–12) cm long, not or shallowly canaliculate above, margins neither raised nor winged; leaflets ovate, oblong, lanceolate, elliptical or falcate, (2–)3–8(–12) cm × (1–)2–3.5(–7) cm, usually increasing in size distally, base obliquely cuneate or truncate, apex acuminate, acute or retuse, glabrous. Inflorescence a terminal or axillary panicle up to 10 cm × 8 cm, mainly on older wood or leafless branchlets, hairy; bracts ovate, up to 3.5 mm × 3 mm. Flowers bisexual, greenish-white, fragrant; pedicel up to 3 mm long; bracteoles 2, valvate, obovate or circular, 4–6(–8) mm × 2.5–4(–5) mm; sepals 5, ovate to triangular, 2–3 mm × 1–2 mm, imbricate; petals 1–2, filiform or linear, up to 2 mm × 1 mm; stamens 10, united to 1–2 mm at the base, filaments 8–10 mm long; ovary superior, style 7–8 mm long. Fruit an oblong to obovate pod 8–14 cm × 2.5–4.5 cm, with a 5–8(–10) mm long beak, flattened, pendulous, thinly woody, smooth, deep brown, purple to blue-black, with sutural wings 3–5 mm wide, up to 8-seeded. Seeds oblong to circular, 10–20 mm × 10–15 mm, flattened.

In DR Congo *Brachystegia floribunda* flowers in (August–)September–October, and has ripe fruits in (June–)July–August.

Brachystegia is a taxonomically difficult genus comprising about 30 species, distributed in tropical Africa. *Brachystegia bakeriana* Hutch. & Burtt Davy is a deciduous shrub or small tree up to 6(–12) m tall, distributed in Zambia and Angola where it forms dense thickets on white Kalahari sands, or often pure stands on margins of wetlands. In Zambia the fibre from its inner bark is used for hut and fence construction and for tying bundles. *Brachystegia bakeriana* is classified as vulnerable in the IUCN Red list of threatened species, due to its limited distribution area and the decline of its habitat. *Brachystegia stipulata* De Wild. is a small tree up to 8(–9) m tall, distributed in DR Congo, Tanzania, Malawi, Zambia and Mozambique. Its bark is made into cords and its wood is used in construction and for making charcoal.

Ecology *Brachystegia floribunda* occurs at 700–2100 m altitude in deciduous woodland, usually with an average annual rainfall above 1000 mm. It is locally abundant, usually dominant, often in pure stands, or co-dominant with *Brachystegia spiciformis* Benth., *Brachystegia longifolia* Benth., *Julbernardia paniculata* (Benth.) Troupin, *Faurea saligna* Harv. and *Uapaca* spp., less often with *Brachystegia boehmii* Taub., *Julbernardia globiflora* (Benth.) Troupin or *Isoberlinia angolensis* (Welw. ex Benth.) Hoyle & Brenan.

Genetic resources and breeding As *Brachystegia floribunda* is fairly widely distributed and locally abundant, it seems not threatened with genetic erosion.

Prospects *Brachystegia floribunda* is a useful local resource, not only yielding fibre but also a range of other products. Detailed information on its properties is not available, making it difficult to assess the prospects of the species.

Major references Brenan, 1967a; Brummitt et al., 2007; Greenway, 1950; Morris, 1996; Wilczek et al., 1952.

Other references Abbot & Lowore, 1999; Bingham, 1990; Campbell, 1996; Kambewa et al., 2007; Lawton, 1980; Malaisse, 1997; Missouri Botanical Garden, undated; Phiri, 1998; Wickens, 1980.

Authors M. Brink

BRACHYSTEGIA LONGIFOLIA Benth.

Protologue Hooker's Icon. Pl. 14: t. 1359 (1881).

Family Caesalpiniaceae (Leguminosae - Caesalpinioideae)

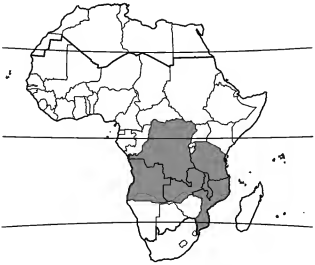
Origin and geographic distribution *Brachystegia longifolia* is distributed in DR Congo, Tanzania, Malawi, Zambia, Angola and Mozambique.

Uses The inner bark is used for making rope; it was formerly used for making bark cloth. In Zambia the bark and root are used for making fishing nets and baskets.

The tree is an important local source of fuelwood, and is used for making charcoal. The wood is also used for tool handles, temporary construction, fences and mine props. The tree provides fodder for cattle. It is also a source of feed for bees and edible caterpillars, and it provides shade.

In traditional medicine a decoction of the root is taken for the treatment of bile problems and stomach-ache. The bark is steeped in cold water for half an hour and the liquid is drunk in case of worms or other stomach problems, or the bark is steeped overnight and used in an enema. The leaves are pounded in water to make a bath for sick children.

Properties The wood is moderately heavy, with a density of about 710 kg/m^3 at 12% moisture content. It is moderately hard. At 12% moisture content, the modulus of rupture is 86 N/mm^2, modulus of elasticity 9900 N/mm^2, compression parallel to grain 48 N/mm^2, shear 13.7 N/mm^2 radial and 12.6 N/mm^2 tangential, and cleavage 9.7 N/mm radial and 9.5 N/mm tangential. The wood is susceptible to borers



Brachystegia longifolia – wild

and not very durable. In papermaking trials the wood yielded pulp of poor quality.
Browse from coppice regrowth in Zambia contained per 100 g dry matter: crude protein 12.1 g, P 190 mg, Ca 480 mg and Mg 270 mg. The bark contains 7–9% tannin.

Botany Deciduous, small to medium-sized tree up to 30 m tall, sometimes a shrub; bole straight, often with conspicuous rounded bosses; outer bark deeply or shallowly fissured longitudinally, often coarsely reticulate, flaking in thick irregular scales, dark grey or dark brown; crown spreading, rounded to obconical or flat; main branches suberect to spreading. Leaves alternate, 7–25 cm long, paripinnately compound with (5–)6–18 pairs of leaflets, the pairs very variable in spacing; stipules intrapetiolar, shortly connate at base, filiform, linear, lanceolate-falcate to subfoliaceous, 10–35 mm × 1–5 mm, caducous, with reniform to subcircular auricles 1–17 mm × 0.5–9 mm, auricles caducous independently of stipules; petiole 1–5 cm long, pulvinate; rachis deeply canaliculate with raised and winged margins; leaflets extremely variable in shape, size and indumentum, narrowly triangular, ovate to oblong, sometimes falcate, the middle leaflet or the one next to the proximal one the largest, the proximal leaflet pair 1–5 cm × 1–2 cm, the middle leaflet pair 2.5–8 cm × 1–3 cm, base obliquely rounded, cordate or truncate, apex acute or rounded, thin, leathery, glabrous or pubescent. Inflorescence a terminal or axillary panicle up to 10 cm long, glabrous or with dark or rusty hairs; peduncle usually slender and terete, rarely grooved; bracts ovate to oblong, 2.5–4 mm × 1.5–3 mm, acute at the apex. Flowers bisexual, greenish white; pedicel up to 2.5 mm long; bracteoles 2, valvate, obovate or orbicular, 6–8 mm × 3–4 mm; sepals 5, oblong, obovate, lanceolate or imbricate, 2–4 mm × 0.5–5 mm, the proximal and lateral sepals often fused; petals 0–4, linear to spatulate, 2.5–3 mm × 0.5 mm; stamens 10, united for 1 mm at the base, filaments 10–20 mm long; ovary superior, style up to 12 mm long. Fruit an oblong to obovate pod 7–20 cm × 2.5–5 cm, rounded to obtuse at the apex with a 4–8 mm long beak, flattened, woody, smooth or scurfy, pale to dark brown, 2–6-seeded, explosively dehiscent. Seeds oblong to ovoid, 12–15 mm × 10–15 mm, flattened, chestnut-brown.
In Zambia *Brachystegia longifolia* flowers mainly in September–December and the fruits ripen in June–September.
Brachystegia is a taxonomically difficult genus comprising about 30 species, distributed in tropical Africa. *Brachystegia taxifolia* Harms is a shrub or small tree up to 12(–16) m tall, distributed in DR Congo, Tanzania, Malawi and Zambia. Its bark is used as tying material, for instance in hut construction. The wood is not durable, but it makes good charcoal. The tree is also a source of feed for bees and edible caterpillars.

Ecology *Brachystegia longifolia* occurs at 200–2100 m altitude in deciduous woodland. It is locally dominant or co-dominant.

Management The plant can be propagated with seedlings or wildlings. It can be coppiced, pollarded and lopped. For the production of bark cloth in Malawi, the bark was stripped off, soaked and beaten out. Blankets were made by sewing together several strips.

Genetic resources and breeding As *Brachystegia longifolia* is fairly widely distributed and locally dominant, it seems not threatened with genetic erosion.

Prospects *Brachystegia longifolia* is a local source of fibre, but detailed information on the properties of the fibre is not available, making it difficult to assess the prospects of the species as a fibre plant. The tree yields a range of other products, of which fuelwood is probably the most important.

Major references Brummitt et al., 2007; Chilufya & Tengnäs, 1996; Ishengoma & Chihongo, 1995; Watt & Breyer-Brandwijk, 1962; Williamson, 1955.

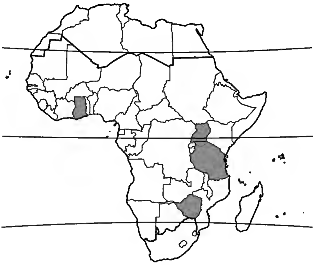
Other references Abbot & Lowore, 1999; Chittenden, Coomber & Morton, 1951; Greenway, 1950; Hibajene & Kalumiana, 2003; Lawton, 1968; Malaisse, 1997; Morris, 1996; Neuwinger, 2000; Wilczek et al., 1952; Wickens, 1980.

Authors M. Brink

BROUSSONETIA PAPYRIFERA (L.) L'Hér. ex Vent.

Protologue Tabl. règn. vég. 3: 547 (1799).
Family Moraceae
Chromosome number $2n = 26$
Synonyms *Morus papyrifera* L. (1753).
Vernacular names Paper mulberry, Ghana yorke, deer's tree, tapa cloth tree (En). Mûrier à papier (Fr). Amoreira do papel (Po).

Origin and geographic distribution The natural distribution range of paper mulberry comprises Japan, China, Indo-China, Thailand, Myanmar and Assam (India). From there it has



Broussonetia papyrifera – planted

been introduced by early voyaging Polynesians to tropical islands throughout the Pacific Ocean and to Indonesia. It is cultivated and has naturalized in Europe and the United States. In tropical Africa it has been introduced in Ghana, Uganda, Tanzania and Zimbabwe sometime during the first half of the 20th century. It is probable that it has since spread to other tropical African countries but this has remained undocumented.

Uses For centuries the tough and interlacing bast fibre from the inner bark of paper mulberry has been used to make paper and textile fabric for clothing. The former application is found in Japan, China, Indo-China, Thailand, Myanmar, the Philippines and Indonesia, although with different production methods, and the latter in, among others, Indonesia, New Guinea and Polynesia, where the fabric is known as 'tapa cloth'. In China paper mulberry fibre was made into a form of paper around 100 AD. Around 600 AD paper manufacturing from paper mulberry reached Japan, where a high-quality paper industry became established. The very strong paper made of paper mulberry bast fibre in Japan is used for writing and the manufacture of lanterns and umbrellas. Both the bark and the wood can be used for the production of newsprint, writing and printing papers.

Introduction of paper mulberry in Africa was done with the purpose to produce fibres specifically for the production of paper. This has not been a success and the main use of paper mulberry in tropical Africa is for firewood and to some extent for timber. In Ghana the timber is used for furniture, crates, pallets, picture frames and plywood. In China the wood is used for furniture.

In Indonesia the young leaves are eaten as a steamed vegetable. The sweetish infructescences are edible as well. The leaves are fed to livestock in Ghana, to pigs in Indo-China and to silkworms in China.

In traditional medicine in Indo-China the leaves are used as a laxative and a diaphoretic, and the fruit as pectoral, stomachic and tonic, whereas the bark is taken against dysentery and haemorrhage and the latex applied externally to treat snake- and dog-bites and bee stings. The root bark is used for the depigmentation of the skin.

Production and international trade In South-East Asia paper mulberry fibres are mainly used locally, and paper making is usually a home industry. In the Philippines handmade paper is produced for domestic use as well as export markets, but production statistics are not available.

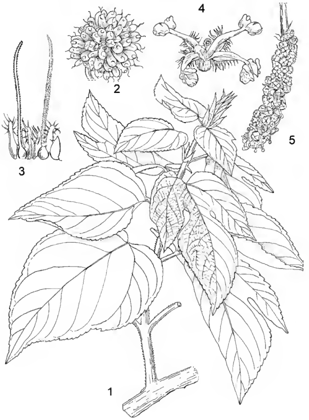
Properties Paper mulberry bast fibres are soft, lustrous and very strong. The fibre cells are (6–)10–15(–25) mm long and (12–)25–30(–36) μm wide. The wood and bark of paper mulberry can be pulped, separately or together, with a number of processes, including the mechanical, kraft and APMP (alkaline peroxide mechanical pulping) processes. Pulping experiments with the whole stem for the production of bleached sulphate and rayon grade pulp have been promising. Bast fibre pulp may be used in blends to increase the tear strength of short-fibred pulps. Interaction of resinous substances with inorganic compounds, especially calcium, may cause ink-repellent spots in paper made from paper mulberry bast fibre.

The wood is greyish white. The grain is straight. Wood from Ghana had a density of 455–506 kg/m^3 at 12% moisture content. The wood is soft, fibrous and brittle. Reports indicate that the timber is non-durable and very weak compared to other timbers with respect to almost all mechanical properties, both in green and air-dried condition. The wood fibres are (0.1–)0.8–1.2(–1.4) mm long and (17–)22–30(–47) μm wide. Oven-dry wood contains 59% cellulose, 23% lignin, 16% pentosans and 1% ash.

The flavonoid broussochalcone A, isolated from the bark, is a powerful antioxidant, and has free radical-scavenging activity. It also suppresses the production of nitric oxide and hence it may have potential to cure various inflammatory diseases. It is also a potent inhibitor of platelet aggregation and an inhibitor of respiratory burst in neutrophils. Several other compounds with activity against platelet aggregation were isolated from the bark of paper mulberry. Broussonin A and B from the bark have shown antifungal and antibacterial activity.

Adulterations and substitutes As many representatives of the family *Moraceae*, like *Artocarpus* spp. and *Ficus* spp., have fibres suitable for backcloth and papermaking, they may substitute paper mulberry fibre. Flax and hemp fibres may be used as substitutes for paper mulberry fibre to reinforce short-fibred pulps.

Description Dioecious, deciduous, medium-sized tree up to 12(–35) m tall, in cultivation often a multi-stemmed shrub c. 3 m tall, with white latex present in all parts; bole with small buttresses, diameter up to 70 cm, generally gnarled; bark smooth, dark grey, inner bark consisting of tough interlacing fibres that can be extracted in broad layers; crown spreading; branchlets 1.5–3 mm thick, short, soft-hairy. Leaves alternate, simple; stipules up to 20 mm long, membranous, slightly ribbed, caducous; petiole up to 10(–15) cm long, hairy; blade ovate or cordiform or elliptical, 5–20 cm × 4–12 cm, entire or up to 5-lobed, rounded or cordate at base, acuminate to sub-acute at apex, papery, lower surface of young leaves dense soft-hairy, pinnately veined with 5–9 pairs of lateral veins. Inflorescence an axillary catkin; male inflorescence solitary or clustered on short axillary shoot, cylindrical, 3–10 cm long, reddish, many-flowered, peduncle 1–2.5 cm long, densely hairy; female inflorescence globose, 1–1.2 cm in diameter, peduncle 0.3–1.5 cm long, hairy. Flowers unisexual; male flowers sessile, perianth 4-lobed, 1.5–2 mm long, stamens 4, 3–3.5 mm long; female flowers covered by bracts, perianth tubular, c. 1 mm long, 4-dentate, ovary superior, c. 0.5 mm long, stigma 1, 7–10 mm long. Fruit an oblongoid drupe, 2–2.5 mm long, 1-seeded, many arranged together in a subglobose infructescence 2–2.5 cm in diameter. Seed small.



Broussonetia papyrifera – 1, leafy twig; 2, male inflorescence; 3, male flower; 4, female flowers and interfloral bracts; 5, infructescence.
Source: PROSEA

Other botanical information *Broussonetia* comprises 8 species, of which 7 are native to tropical, subtropical and warm temperate regions of Asia, and 1 is native to Madagascar.

Anatomy The inner bark is about 2 mm thick; it is dense and homogeneous because of the minute pith rays. The fibre cells have thick walls and their ends are usually pointed or blunt, though other shapes may also occur. Dislocations and cross-markings are frequent but finer than those in flax (*Linum usitatissimum* L.) and hemp (*Cannabis sativa* L.) fibre. The bark also contains a second type of fibre cells, which are wide, thin-walled and ribbon-like, with rounded ends. Paper mulberry fibres are often enveloped by a transparent membrane (the loosened primary wall), which distinguishes the fibres of this species from those of many other bast fibre species. Parenchyma with cells containing prismatic calcium oxalate crystals and milksap tubes (lactifers) are also found in the bark.

Growth and development Paper mulberry is a fast-growing tree, with often abundant sucker formation. An annual growth in height of 2.6 m and in diameter of 2.5 cm has been recorded. Various leaf forms may occur on the same twig: from ovate with entire margins to lobed on one or both sides. Flowering and fruiting can occur year-round, but trees exploited for their fibres are mostly cut before they reach the flowering stage. In many of the Pacific Ocean Islands flowering is unknown or infrequent. Paper mulberry trees can regenerate new bark after complete girdling. In Uganda the paper mulberry is one of the fastest growing tree species recorded. Chimpanzees, birds and other animals eat the infructescences and contribute to dispersal of the seeds.

Ecology *Broussonetia papyrifera* grows in areas with an average annual temperature of 12–30°C, a mean annual rainfall of 700–2500 mm, and a dry season of up to 4 months. In its native range it occurs in warm temperate to subtemperate deciduous forest, but it also thrives in tropical lowlands and highlands, in particular in areas with a seasonal climate. It is a vigorous pioneer which can spread rapidly following canopy disturbance or farming and it is sometimes considered a weed, for example in Bangladesh and the Philippines. The species was introduced in Uganda for experimental purposes. The experiment failed, trials were abandoned and the species spread. In Budongo Forest, Uganda, paper mulberry is regenerating in disturbed areas and it is also reported as naturalized in other Ugandan forests. In Ghana canopy gaps and farming activities favour its spread and it has gained a reputation as one of the most serious invasive weeds.

Propagation and planting Natural reproduction of paper mulberry is by seed and root suckers, and in cultivation also by wood or root cuttings, layering or grafting. The 1000-seed weight is c. 2 g. Seeds are not very sensitive to light for germination and can germinate in the dark. In Thailand transplanting of suckers 30 cm tall gave better survival than propagation with root cuttings, stem cuttings or seed. In-vitro micropropagation of paper mulberry is possible as well.

Management For the production of bark cloth or tapa cloth without holes it is necessary to prune the side branches. So far efforts in tropical Africa to control *Broussonetia papyrifera* are minimal. Herbicide treatment is considered for control in forest reserves in Ghana. It is promoted in some places for firewood because of its rapid growth. In tea estates in Uganda it is replacing *Eucalyptus* spp. and other species for firewood, and pure stands are established next to a nature reserve such as Mabira Forest.

Diseases and pests No information is available on diseases and pests affecting paper mulberry in tropical Africa.

Harvesting In Japan stems from coppiced paper mulberry are usually harvested every 3–5 years. In Polynesia stems 3–4 m tall and less than 4 cm in diameter are harvested, leaving the stump to coppice. Usually there are 12–18 months between harvests. In Indonesia the harvest interval is 2 years and stems of 2–3 m tall and a diameter of 2 cm are cut off at the base of the trees. For fibre use timely harvesting is necessary because older trees have a harder and more brittle bark.

In Ghana the stems are harvested as timber and fuelwood while the leaves are used as fodder. Depending on the diameter of the trees, chainsaw or cutlasses are used for felling.

Yield A two-year old paper mulberry plantation in Indonesia at 800 m altitude yielded 300 g of fresh bark per tree, which is equivalent to 90 g dry bark fibre. In Thailand paper mulberry spaced 1 m × 1 m apart and harvested 6 and 12 months after planting yielded 2400 and 2800 kg bark per ha, respectively. In production for pulp and paper, annual yields of 8–12 t/ha can be expected in low rainfall areas and 20–30 t/ha in high rainfall areas.

In Ghana the average dimensions of the utilizable portion of the timber harvested from Afram Headwaters Forest for milling were: butt diameter 46 cm; top diameter 30 cm; length 19.6 m. The average log and lumber recoveries were 61.9% and 59.7% respectively when a horizontal narrow bandmill (Wood-Mizer) was used.

Handling after harvest In Japan the stems are steamed and the outer bark is scraped off to be used for the production of coarse paper but elsewhere the outer bark is discarded. Complicated and labour-intensive procedures are used to process the inner bark to be used for clothing or paper. On islands of the Pacific Ocean the general procedure in the manufacture of tapa cloth is to peel bark strips off the stem and to remove the outer bark. After being soaked in water and cleaned, the strips are placed on a log and beaten. Individual strips are united by overlapping the edges and beating them together. Depending on the thickness, the appearance varies from muslin-like to leathery. Tapa cloth is often dyed or otherwise ornamented. In Ghana the major machining defect of the timber was fuzzy grain.

Genetic resources No germplasm collections of paper mulberry are known to exist. In South-East Asia cultivars of paper mulberry include those with laciniate leaf blades, white infructescences, yellow or white variegated leaves, or relatively large leaves. In Hawaii, where only male plants have been introduced, 3 different clones are named. In many Pacific Ocean Islands the bark is no longer traditionally used for tapa cloth, cultivation has ceased and often the species has not persisted in the wild. It is feared that many local selections have disappeared. In Tonga, Samoa and Fiji the species is still cultivated and in Hawaii the traditional tapa cloth production has been revived.

Breeding No breeding programmes of paper mulberry are known to exist.

Prospects Wherever introduction of paper mulberry would be considered, the risk that it will develop into an invasive weed should be taken into account. In many instances vegetative multiplication of male plants only is a good option to avoid problems. The exploitation, especially as a source of raw material for speciality papers, e.g. for decoration and currency notes, could have some future and economic potential in tropical Africa. Production could be increased by using adapted cropping methods, the selection of appropriate cultivars and improved processing methods. Compounds from the bark may have some therapeutic potential in inflammatory diseases. Paper mulberry is considered as a promising 'second-generation' biofuel crop species.

Major references Berg, 2003; CAB International, 2010b; Dweck, undated; Ilvessalo-Pfäffli, 1995; Orwa et al., 2009; Whistler & Elevitch, 2006; Wu, Zhou & Gilbert, 2004.

Other references Addo-Fordjour et al., 2009; Appiah, 2008; Bakuneeta, 1997; Bhat & Guha, 1952; Cheng et al., 2001; Dale, 1953; Dawkins, 1956; FOREAIM, 2008; Lee et al., 2001; Ofori, 2008; Owusu, 2008; Sheil, 1994; Suleman & Nadeem, 1995; Zheng et al., 2008.

Sources of illustration Berg, 2003.

Authors F.W. Owusu

Based on PROSEA 17: Fibre plants.

BULBOSTYLIS HISPIDULA (Vahl) R.W.Haines

Protologue Sedges & Rushes E. Afr., App. 3: 1 (1983)

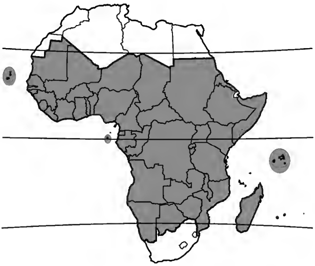
Family Cyperaceae

Chromosome number $n = 5$

Synonyms *Scirpus hispidulus* Vahl (1805), *Fimbristylis exilis* (Kunth) Roem. & Schult. (1817), *Fimbristylis hispidula* (Vahl) Kunth (1837), *Abildgaardia hispidula* (Vahl) Lye (1974).

Vernacular names Mshinda (Sw).

Origin and geographic distribution *Bulbostylis hispidula* is very common in tropical Africa, rare in tropical America and very rare in South-East Asia.



Bulbostylis hispidula – wild

Uses *Bulbostylis hispidula* is sometimes used for making mats. It is recorded to be grazed a little by cattle in Senegal, but not by cattle and goats in Uganda. In Namibia the leaves are used as a sieve for straining marula (*Sclerocarya birrea* (A.Rich.) Hochst.) wine or beer. In traditional medicine in Benin a decoction of the whole plant is taken for the treatment of amoebic dysentery. The whole plant is burnt together with the leaves of *Cordia africana* Lam. to fumigate fingers affected by handling cotton thread. In Tanzania a leaf infusion is taken for the treatment of fractures.

Properties The rhizome is fragrant.

Botany Tufted herb, either annual or perennial with a woody rhizome; stems up to 50(–80) cm tall, c. 0.5(–1.5) mm in diameter, angular, hairy or glabrous. Leaves inserted at the base of the stem; sheath pale green, densely hairy to almost glabrous, with long hairs at the openings; ligule absent; blade filiform, usually less than 15 cm × 0.5 mm, frequently only 1–2 cm long, flat or channeled, usually hairy. Inflorescence a terminal, simple or compound, lax, umbel-like anthela of 1 sessile spikelet with 2 to many stalked spikelets or additional groups of sessile and stalked spikelets, rarely all spikelets almost sessile; involucral bracts usually shorter than inflorescence. Spikelets ovoid to elongate, 4–15 mm × 2–4 mm, 10–15-flowered; glumes imbricate, ovate-lanceolate, 2–5 mm long, margin and surface with minute hairs, pale to dark red-brown or almost black, often with paler margins and midvein; flowers bisexual, perianth absent, stamens 1–3, ovary superior, 1-locular, stigmas 3. Fruit an obovate nutlet 1–1.5 mm × c. 1 mm, obtusely 3-angled, with 5–10 rounded, transverse wrinkles on each side, angles smooth or papillate, pale grey to pale brown, 1-seeded.

In Senegal *Bulbostylis hispidula* flowers in (May–)July–October(–November), and in Benin it flowers and fruits in April–November. *Bulbostylis hispidula* is an extremely variable species with at least 6 subspecies recognized in tropical Africa, but these are sometimes difficult to distinguish. Important diagnostic characters for the various subspecies are the annual or perennial character, the robustness of the culms, the length of the glumes and flowering parts, the shape and ornamentation of the nutlets, and the size and shape of surface cells of the fruit.

Bulbostylis comprises about 150 species and distributed throughout the tropics. *Bulbostylis filamentosa* (Vahl) C.B.Clarke (synonyms: *Abildgaardia filamentosa* (Vahl) Lye, *Bulbostylis metralis* Cherm.) is a perennial, tufted herb with a short rhizome and stems up to 100 cm tall, distributed throughout tropical Africa. In Ghana whole plants are used as brooms. *Bulbostylis pilosa* (Willd.) Cherm. (synonym: *Abildgaardia pilosa* (Willd.) Nees) is a perennial, tufted herb with a woody rhizome and stems up to 90 cm tall, widely distributed in tropical Africa. In Ghana stems and whole plants are used as brooms.

Ecology *Bulbostylis hispidula* occurs from sea-level up to 2050 m altitude in a large variety of habitats, including dry grassland, seasonally wet grassland and woodland, shrubland, forest openings, dry sandy locations, dunes, shallow soil on rocks, marshes and shores of lakes. It often occurs in fallows and other disturbed habitats, and is a weed of wet rice and upland crops.

Management *Bulbostylis hispidula* is collected from the wild.

Genetic resources and breeding As *Bulbostylis hispidula* is widely distributed, very common, and growing in a wide range of habitats, it is not threatened with genetic erosion.

Prospects *Bulbostylis hispidula* is a widely distributed but little used species, which is unlikely to become more important in the future.

Major references Burkill, 1985; Goetghebeur & Coudijzer, 1985; Lye, 1997a; Simpson & Inglis, 2001; Vanden Berghen, 1988.

Other references Abbiw, 1990; Adjanohoun et al., 1989; Akoègninou, van der Burg & van der Maesen, 2006; Eastern Arc Mountains & Coastal Forests CEPF Plant Assessment Project Participants, 2006; Hoenselaar, Verdcourt & Beentje, 2010; Kern, 1974; Lye, 1995; Lye, 1996a; Roalson, 2008; SEPASAL, 1999.

Authors M. Brink

CALAMUS DEËRRATUS G.Mann & H.Wendl.

Protologue Trans. Linn. Soc. London 24(3): 429 (1864).

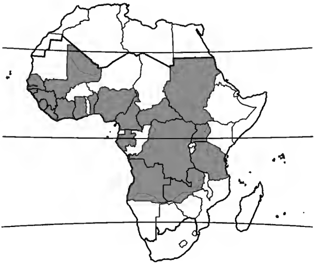
Family Arecaceae (Palmae)

Synonyms *Calamus barteri* Drude (1895), *Calamus heudelotii* Drude (1895), *Calamus leprieurii* Becc. (1902), *Calamus perrottetii* Becc. (1902), *Calamus schweinfurthii* Becc. (1902), *Calamus laurentii* De Wild. (1904), *Calamus akimensis* Becc. (1908), *Calamus falabensis* Becc. (1908).

Vernacular names Rattan, rattan palm (En). Rotin (Fr). Rotim (Po).

Origin and geographic distribution *Calamus deërratus* is the most widely distributed of the African rattans and is distributed across the humid forest zone of Africa, from Gambia and Senegal eastwards to southern Sudan, Uganda and Tanzania, and southwards to northern Angola and Zambia. It is not cultivated.

Uses Throughout West Africa in particular, *Calamus deërratus* has a wide range of uses for furniture, construction and basketry. Whole stems are also made into walking-sticks and musical instruments. In Ghana they are woven into screens for fencing. In Nigeria stems of *Calamus deërratus* were formerly supplied to prisons for workshop activities and the rehabilitation of prisoners. Whole stems were widely used for building houses and fences in Nigeria as well as in Ghana. In Zambia and Uganda in the absence of large-diameter stems, rattan furniture frames are made of two or three stems of *Calamus deërratus* joined together. Both whole and split stems are used to make traditional suspension bridges and foot-loops



Calamus deërratus – wild

for climbing palm trees. Split stems are made into a wide range of products, such as baskets, chair seats, bow strings, and fish traps and weirs, and they are used for tying house frames, rafters, thatch and fences. In the continental region of Equatorial Guinea, for instance, they are used in the fabrication of temporary market baskets. They have also been used for the fabrication of tie-ties for the staking of yams. In Nigeria split stems were formerly used to tie timber trees together prior to floating them downriver. The stem bark makes a strong rope. In Sierra Leone, the stem bark is twisted into little sponges and used to clean pans. In Ghana the leaves are often used for thatching. The leaf sheath may be peeled off and twisted to make a rough rope.

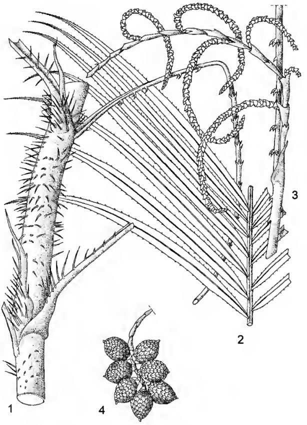
The apical bud (palm heart) is eaten in Sierra Leone and Ghana and roasted young shoots are eaten in Ghana. Ash from burned roots is used as a kitchen salt in Guinea and Ghana. In Senegal the leaves are grilled over a fire and then macerated, and the liquid is drunk to promote weight loss; the same preparation is also given for the treatment of oedema caused by vitamin deficiencies.

Production and international trade *Calamus deërratus* is locally traded in West Africa, East Africa and southern Africa (Zambia and Zimbabwe), but there are no reports of trade in Central Africa. It is not internationally traded.

Properties *Calamus deërratus* is only utilized in the absence of other rattan species with more desirable qualities with respect to flexibility and durability. Throughout its range, its stems are considered inferior to other lianous palms, as they are not as robust as many of the larger *Laccosperma* spp., and less flexible than many *Eremospatha* spp. At 12% moisture content stems from Nigeria had a modulus of rupture of 41 N/mm^2 and a modulus of elasticity of 3400 N/mm^2. Per 100 g dry matter the stem contains: energy 1023 kJ (244 kcal), protein 6.0 g, fat 1.2 g, carbohydrate 67.1 g, fibre 19.0 g, ash 12.0 g, Ca 200 mg, P 500 mg, Fe 25 mg. Air-dried samples of the stems in Nigeria were recorded to contain per 100 g: water 15.0 g, energy 1324 kJ (316 kcal), protein 4.6 g, fat 0.6 g, carbohydrate 77.8 g, ash 1.9 g, Ca 138 mg, Mg 52 mg.

Adulterations and substitutes The stems of *Calamus deërratus* are not as widely used as those of *Laccosperma* and *Eremospatha* spp. However, the use of *Calamus deërratus* increases in the absence of other rattans and because *Calamus deërratus* also contributes to other household needs, aside from a wide range of construction and weaving applications.

Description Dioecious, clustering, slender to moderately robust rattan palm, climbing up to 20 m high, often branching sympodially at the base, forming dense clumps; stem erect, prostrate or scandent, up to 30 m long, 7–30 mm in diameter without sheaths, 12–35 mm with sheaths, internodes (8–)15–20 cm long. Leaves pinnately compound, up to 1.5(–1.75) m long; sheath varied in armature from almost unarmed to densely covered with triangular, dark brown or black spines up to 3 cm long, mature sheath with brown or grey indumentum; ocrea 8–10(–12) cm long, dry, papyraceous, tongue-shaped, often longitudinally splitting and reflexed, becoming unrecognisable, armed on the margins with spines more pale and bristle-like than those on the leaf-sheath, rarely unarmed; flagellum up to 3.5 m long, armed with small recurved thorns; petiole up to 20 cm long, rounded abaxially, concave adaxially, variously armed with large black spines up to 3 cm long and small recurved black thorns; rachis armed as petiole, spines



Calamus deërratus – 1, part of stem; 2, part of leaf; 3, part of inflorescence; 4, fruits.
Redrawn and adapted by Achmad Satiri Nurhaman

becoming sparse distally, cirrus absent; leaflets up to 30 on each side of the rachis, linear-lanceolate, up to 35 cm × 2 cm, bluntly compact at the base, finely acuminate to apiculate at the apex, single-folded, concolorous or with slightly darker green upper surface, with bristles on leaflet margins and veins. Inflorescence axillary; male and female inflorescences similar, up to 3.5 m long, with 1–4 partial inflorescences and a long terminal flagellum; axis and bracts armed throughout with reflexed, solitary or grouped black spines; bracts tightly sheathing, up to 70 cm long with an expanded, papyraceous limb c. 5 cm long; partial inflorescences up to 40 cm long, with up to 15 or more rachillae on each side, subtended by bracts c. 2 cm long; rachillae up to 7 cm long, arcuate, arranged distichously; bracts distichous, dull brown in colour, ciliate-hairy around the mouth; in male inflorescence flowers solitary, in female inflorescence flowers in pairs of 1 female flower and 1 sterile flower. Flowers unisexual; male flower symmetrical, with minute involucre to 1 mm long, calyx tubular at base, 4 mm long, 3-lobed, corolla with 3 valvate lobes up to 7 mm long, fused at the base for c. 1 mm, stamens 6, pistillode minute or absent; sterile flower very similar to fertile male one but slightly shorter and narrower and with empty anthers; female flower with calyx tubular at first and then splitting as ovary increases in size, lobes c. 3 mm long, corolla with 3 valvate lobes c. 5 mm long, staminodes 6, epipetalous, ovary c. 5 mm × 2.5 mm, tipped by 3 stigmas c. 1 mm long, recurved at anthesis. Fruit globose, up to 2 cm × 1 cm, with a beak up to 2 mm long tipped by remains of the style, with 16–21 vertical rows of scales, 1-seeded. Seed flattened laterally, c. 9 mm × 8 mm × 5 mm.

Other botanical information *Calamus* comprises about 370 species, distributed from West Africa to South-East Asia, Australia and Fiji. Recent examination of herbarium specimens and field observations made it clear that *Calamus* in Africa is represented by a single polymorphic species. The fact that *Calamus* in Africa has been the cause of some taxonomic problems has been due to the recognition of poorly-defined infraspecific variation.

Anatomy The cross section of the stem shows three distinct regions: epidermis, cortex and central cylinder. The epidermal cells are rectangular, 15–26 µm long and 7–11 µm wide, with stomata in the cuticular layer. Two layers of unlignified parenchyma cells below the epidermis are assumed to be the hypodermis. The cortical zone is 6–10 cells wide, the cells being of varying sizes, rectangular with rounded corners, lignified and interconnected. The cortex is interspersed with small fibre bands. The central cylinder is composed of vascular bundles embedded in ground parenchyma. The outer vascular bundles of the central cylinder are incomplete whilst the inner ones are complete and diffusely arranged. The vascular bundles consist of conducting tissue (xylem and phloem), surrounded by a fibre sheath and parenchyma. A complete vascular bundle contains one metaxylem vessel with a diameter of 68–337 µm, protoxylem consisting of a cluster of 2–5(–10) vessels, and two phloem fields each containing 4–6 sieve tubes. The fibre sheath surrounding the bundle is relatively extensive in peripheral vascular bundles but forms only a small border in the inner vascular bundles. The fibre cells are 0.6–4.2 mm long and 5.8–34.8 µm wide, with a lumen width of 2.9–29 µm and a cell wall thickness of 1.5–20.37 µm. The ground tissue parenchyma is polygonal and rectangular in shape and corresponds to the 'net-like' type in transverse section and in longitudinal section resembles 'coins in a pile'.

Growth and development *Calamus deërratus* climbs by means of flagellae, arising directly from the sheath. In experiments in Ghana eleven-month old seedlings had a growth rate of about 7 cm in 20 weeks. In Benin flowering and fruiting is in December. All *Calamus* species are pleonanthic, i.e. the stems do not die after flowering.

Ecology *Calamus deërratus* has a strong preference for swamp and riverine forest and is less common in areas with high rainfall. As such, it is relatively rare in the Guineo-Congolian forest of Cameroon and Gabon. It is more common in drier gallery forest in the transition zones to the Sudanian savanna woodland in the north, and to the Zambezian savanna woodland in the south. *Calamus deërratus* occurs in West and Central Africa up to 500 m altitude, and in East Africa up to 1500 m altitude. It is usually found in forest under a canopy, but also occurs in open areas where it often forms dense thickets. Swamp forests with *Calamus deërratus* in Uganda are prone to seasonal fires, which is partly aggravated by the rattan harvesters leaving the upper parts of the rattan stems in the canopy.

Propagation and planting Seeds germinate better when the sarcotesta has been removed, but soaking of the seeds in concentrated sulphuric acid or ethyl alcohol is detrimental. In Ghana *Calamus deërratus* has been successfully propagated using rhizomes, with about 20% sprouting.

Management *Calamus deërratus* is harvested solely from the wild. Indigenous management systems for the rattan resource in Africa are unknown, and, throughout its range, rattan is considered an open-access resource; there are very few, if any customary laws regulating its harvest. This is mirrored in the lack of national legislation for most countries.

Harvesting The conditions and circumstances under which rattan species in Africa are harvested and transported are remarkably consistent. The majority of the harvesting for commercial trading is undertaken by individuals as a secondary source of income. Despite the recognised capital returns of rattan harvest and sale, the unpleasant and difficult nature of rattan harvesting means that most harvesters state that they would prefer to concentrate on their primary occupations given the opportunity. Most rattan harvesters are local, people from elsewhere often have to pay a small amount to the local chief.

Handling after harvest Processing of raw cane entails the removal of the epidermis (skin) from the stem with a knife and the drying of the raw cane prior to its use. Immature stems, or the very apex of mature stems, where the leaf sheath is also present, are not used and are often left or discarded at the time of harvest. Drying is usually done in the open air. This rudimentary way of processing is not only labour intensive, but also results in inferior quality cane.

Genetic resources *Calamus deërratus* has a wide distribution and is not considered threatened, according to IUCN criteria. Although many rattan species respond well to selective logging activities, logging has also resulted in increased rattan exploitation. The development of a wide network of logging roads throughout many forest areas in West and Central Africa has enabled greater access, and logging trucks are often responsible for the transport of harvested rattan.

Prospects *Calamus deërratus* will remain a very useful local source of rattan, although it is usually considered inferior to other African rattan species. In general, there is growing interest in the rattans of Africa owing to their importance in the livelihoods of rural as well as urban people. Research on rattans in Ghana, Nigeria and Cameroon has shown that cultivation is ecologically feasible, but hampered by socio-economic and socio-cultural factors such as land tenure and perceptions of unlimited wild supplies.

Major references Abbiw, 1990; Burkill, 1997; Dransfield, 1986; Ebanyenle & Oteng-Amoako, 2003; Sunderland, 2001b; Sunderland, 2007; Sunderland et al., 2003; Sunderland et al., 2005; Tenati, 2003; Vanden Berghen, 1988.

Other references Ahn, 1961; Defo, 1997; Defo, 1999; Ebanyenle & Oteng-Amoako, 2005; Falconer, 1994; Gyimah, 1997; Hall & Swaine, 1981; Irvine, 1952; Irvine, 1961; Letouzey, 1978; Lucas & Dahunsi, 2004; Malaisse, 1997; Morakinyo, 1995a; Omagor, 1999; Oteng-Amoako & Obiri-Darko, 2003; Profizi, 1986b; Profizi, 1999; Richards, 1963; Sunderland, 1998b; Sunderland et al., 2008.

Sources of illustration Sunderland, 2001b.

Authors T.C.H. Sunderland

CAMPYLOSPERMUM SQUAMOSUM (DC.) Farron

Protologue Bull. Jard. Bot. Etat 35: 402 (1965).

Family Ochnaceae

Chromosome number $2n = 24$

Synonyms *Gomphia squamosa* DC. (1811), *Ouratea squamosa* (DC.) Engl. (1876).

Origin and geographic distribution *Campylospermum squamosum* occurs from Gambia to Côte d'Ivoire and in Nigeria. It possibly also occurs in Gabon and Congo.

Uses The strong and very flexible young saplings are used in Liberia to bind the drum-head onto hollow log drums. In Liberia the bark or pounded leaves are used in poultices to relieve bodypain.

Production and international trade *Campylospermum squamosum* is only used locally.

Properties No information is available on properties of the fibre or the medicinal properties of *Campylospermum squamosum*.

Botany Straggling shrub or small tree. Leaves alternate, simple, variable in shape; stipules axillary, triangular, partially merged together, 1–1.5 mm long, awned, persistent; blade oblong to oblong-lanceolate, 18 cm × 6 cm, base tapering, apex rounded to acute, margin slightly toothed, midvein and lateral veins prominent above. Inflorescence a branched raceme with several, persistent basal bracts; branches thin and sometimes very long. Flowers solitary or in bunches, bisexual, glabrous;

sepals 5, imbricate, persistent on fruit; petals 5, bright yellow; stamens 10; ovary deeply 5-lobed, 5-locular. Fruit composed of 5 drupelets.
Campylospermum comprises about 35 species and is in need of a taxonomic revision.

Ecology *Campylospermum squamosum* occurs from sea-level up to 1400 m altitude, on brook and river sides, in gallery forest, coastal scrub, in degraded forest on slopes with *Tylophora sylvatica* Decne., *Rhaphiostylis beninensis* (Hook.f. ex Planch.) Planch. ex Benth. and *Microdesmis keayana* J.Léonard, and in secondary forest with *Vernonia conferta* Benth. and *Dalbergia afzeliana* G.Don.

Management *Campylospermum squamosum* is only collected from the wild.

Genetic resources and breeding Information on *Campylospermum squamosum* is too inadequate to assess its genetic vulnerability.

Prospects *Campylospermum squamosum* is likely to remain of occasional local use only.

Major references Aubréville, 1959a; Burkill, 1997; Farron, 1968; Keay, 1954e.

Other references Fedorov, 1974; Neuwinger, 2000.

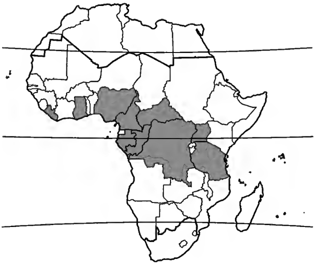
Authors L.P.A. Oyen

CAMPYLOSTEMON LAURENTII De Wild.

Protologue Miss. Ém. Laurent 1: 240 (1906).

Family Celastraceae (Hippocrateaceae)

Origin and geographic distribution *Campylostemon laurentii* is distributed in Liberia, Ghana, Nigeria, Cameroon, the Central African Republic, Gabon, Congo, DR Congo and Cabinda (Angola), as well as in Uganda and Tanzania.



Campylostemon laurentii – wild

Uses In DR Congo the stems of *Campylostemon laurentii* are used for tying. The stem is specifically used as a belt to assist in climbing oil palms (*Elaeis guineensis* Jacq.) for harvesting.

Botany Woody liana up to 35 m tall; old main stem angular, up to 25 cm in diameter; bark warty, shiny; young branches opposite, at right angle with stem, tips often enrolled tendril-like, glabrous. Leaves opposite, simple; stipules very small, early caducous; petiole 5–18 mm long; blade ovate to ovate-lanceolate, 5–23 cm × 2.5–13 cm, rounded at base, acuminate to mucronate at tip, margin dentate, 5–9 pairs of secondary veins, veins pale. Inflorescence an axillary or pseudo-terminal panicle consisting of paired cymes, dense, glabrous; peduncle of cymes 1–6 cm long, branched 3–8 times. Flowers bisexual, crowded in inflorescence, red or pink turning ochre-yellow to whitish, 5–10 mm in diameter; pedicel 2–5 mm long; sepals 5, ovate, unequal, up to 2 mm × 2 mm; petals 5, free, spatulate, 3–4.5 mm × 1.5–2 mm; stamens 5, filaments curved inward, fused at base; ovary 3-celled, style 3-lobed, very short. Fruit consisting of (up to) 3 ovate-lanceolate, flat mericarps 6–9 cm × 3.5–4 cm, each dehiscent with 2 valves and c. 12-seeded. Seeds linear, with an ovate, glabrous wing c. 5 cm long. Seedling with hypogeal germination.
Campylostemon comprises about 9 species. As the description of several species is based on scanty collections and geographic distribution is not continuous, a revision is desirable based on a larger number of herbarium specimens.

Ecology *Campylostemon laurentii* occurs up to 1000 m altitude in a wide variety of habitats such as forest edges, rocky soils, xerophyllous scrub, and in gallery, dry and swampy forests.

Genetic resources and breeding In view of its wide distribution and variety of habitats, *Campylostemon laurentii* is not threatened with genetic erosion.

Prospects The plant will probably remain of local importance only.

Major references Hallé, 1962; Wilczek, 1960a.

Other references Hallé, 1986; Hawthorne & Jongkind, 2006; Lebrun & Stork, 2010; Loesener, 1937; Mildbraed, 1934; Robson et al., 1994.

Authors C.H. Bosch

CAPERONIA FISTULOSA Beille

Protologue Bull. Soc. Bot. France 55, Mém. 8b: 73 (1908).

Family Euphorbiaceae

Chromosome number $2n = 22$

Origin and geographic distribution *Caperonia fistulosa* is distributed from Mali eastwards to Somalia and southwards to Namibia, Botswana, Zambia and Malawi.

Uses The stems of *Caperonia fistulosa* yield fibres used in Mali for making fishing-lines. In Sudan the fibres are used in the construction of cattle sheds.

Botany Monoecious annual herb up to 90(–150) cm tall; stem erect or ascending, slightly branched, hollow, up to 1 cm thick. Leaves alternate, simple; stipules ovate to ovate-lanceolate, up to 8 mm × 5 mm; petiole up to 2 cm long; blade broadly lanceolate, up to 12 cm × 4 cm, base cuneate to rounded, apex (sub-)acute, margin toothed, sparingly appressed hairy, 3–5-veined at the base. Inflorescence an axillary spike with female flowers at the basal part, male flowers towards the top, up to 10 cm long, bracts like stipules but smaller. Flowers unisexual, pedicels short; male flowers with calyx (sub-)glabrous, closed in bud, later splitting in 5 lobes, petals 5, imbricate, free, white, stamens 10, partially fused into a column; female flowers with 5–10 sepals, imbricate, 3–8 mm × 1–4 mm, petals 5–6, white, ovary sessile, 3-locular, subglobose, c. 1 mm in diameter, styles 3, 1–2 mm long, usually free at base, white. Fruit a 3-lobed capsule, 5 mm × 7–9 mm, short, coarse-hairy, green. Seeds globose, c. 3 mm in diameter, smooth, usually grey.

In Benin flowering and fruiting are in March–December.

In the genus *Caperonia* c. 34 species are recognized with 5 poorly differentiated species in continental tropical Africa, 1 species in Madagascar and the majority of species in tropical America.

Ecology *Caperonia fistulosa* occurs in swamps and seasonally flooded areas often on vertisols and usually from low altitudes up to 1000 m above sea-level.

Management *Caperonia fistulosa* is an important weed on vertisols. It shows resistance to glyphosate but can be easily controlled by hand weeding. Other species from the genus are harmful weeds in the Americas and much information is available on how to control these weeds in soya bean (*Glycine max* (L.) Merr.) cultivation.

Genetic resources and breeding As *Caperonia fistulosa* is widespread and apparently common in its habitat, it is unlikely to be threatened with genetic erosion.

Prospects *Caperonia fistulosa* will remain locally important for its use as a source of fibre, but expansion of its use is not likely.

Major references Burkill, 1994; Govaerts, Frodin & Radcliffe-Smith, 2000; Radcliffe-Smith, 1996.

Other references Akoègninou, van der Burg & van der Maesen, 2006; Bertrand, 2005; Keay, 1958b; Miller & Webster, 1966; Radcliffe-Smith, 1989; Radcliffe-Smith, 2001.

Authors C.H. Bosch

CASEARIA BARTERI Mast.

Protologue Fl. Trop. Afr. 2: 494 (1871).

Family Flacourtiaceae (APG: Salicaceae)

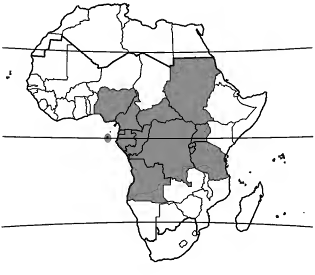
Chromosome number $2n = 44$

Synonyms *Casearia mannii* Mast. (1871), *Casearia runssorica* Gilg (1913), *Casearia noldei* A.Fern. & Diniz (1958).

Origin and geographic distribution *Casearia barteri* occurs in the Lower Guinean and Congolian rainforest areas from Nigeria eastward to Sudan, and southward to Angola and Tanzania.

Uses In West Africa the branches are used to make chew-sticks. In Burundi decoctions of the leaves are drunk against fever and madness. In DR Congo the fruits are used as a fish poison.

Properties Phytochemical screening of the plant for active compounds gave positive results for saponins only.



Casearia barteri – wild

Botany Small to medium-sized tree, up to 20(–40) m tall; bole cylindrical, up to 40(–60) cm in diameter; bark greyish-brownish, slightly rugose; branches more or less horizontal; branchlets prismatic-angular, glabrous at tips. Leaves alternate, entire; petiole 1–1.5 cm long; blade ovate-oblong or oblong, (5–)7–14(–28) cm × (3–)4–6(–10) cm, base broadly cuneate or sometimes almost rounded and usually slightly unequal-sided, apex subacuminate, coriaceous, smooth and shiny above, lateral veins in 6–7(–10) pairs, curved, prominent beneath, tertiary veins laxly prominent-reticulate beneath. Inflorescence axillary, fascicled or glomerate, from a subglobose many-bracteolate cushion, glabrous. Flowers bisexual, small, greenish; pedicel 3(–5) mm long; calyx-lobes 5, c. 3 mm long, petals absent, stamens c. 10, alternating with filiform staminodes; ovary ovoid, attenuate to a short style. Fruit subglobular to broadly ellipsoid, somewhat trigonous, (1.5–)2–2.5(–3) cm × 1.5(–2) cm, yellow-orange, few-seeded. Seeds enveloped in a soft, membranous aril; testa crustaceous.

In Ghana *Casearia barteri* flowers in July–September and bears fruits in September–December.

Casearia comprises about 180 species and occurs in all tropical and subtropical regions. In tropical Africa approximately 15 species can be found, most of them in mainland Africa and a few in Madagascar and the Mascarene islands. *Casearia prismatocarpa* Mast. (synonym: *Casearia dinklagei* Gilg) is a very similar species that has been considered conspecific with *Casearia barteri*. It is a tree up to 20 m tall, occurring in the rainforest area from Sierra Leone to DR Congo. Its twigs are used in Ghana as chew-sticks and in Liberia the leaves are taken as a purgative.

Ecology *Casearia barteri* occurs from sea level up to 2450 m altitude in rainforest, swampy, flooded, half deciduous and secondary forests, gallery forest and wooded savanna.

Management The twigs are only collected from the wild.

Genetic resources and breeding *Casearia barteri* is listed in the IUCN Red list as Lower Risk/least concern, but this needs to be updated in view of the current circumscription of the species.

Prospects It is unlikely that *Casearia barteri* will gain importance as a fibre plant in the future.

Major references Aubréville, 1936; Breteler, 2008; Burkill, 1994; Hul, 1995; Sleumer, 1971.

Other references Baerts & Lehmann, 1989; Bouquet & Debray, 1974; Chase et al., 2002; Elujoba, Odeleye & Ogunyemi, 2005; Irvine, 1961; Neuwinger, 2004; Osho, 1996; Sleumer, 1975; Sleumer & Bamps, 1976; World Conservation Monitoring Centre, 1998.

Authors L.P.A. Oyen

CEIBA PENTANDRA (L.) Gaertn.

Protologue Fruct. sem. pl. 2: 244 (1791)

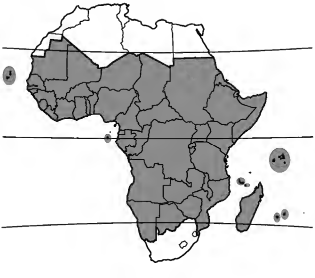
Family Bombacaceae (APG: Malvaceae)

Chromosome number $2n = 72–88$

Synonyms *Eriodendron anfractuosum* DC. (1824).

Vernacular names Kapok tree, silk-cotton tree (En). Fromager, arbre à kapok, ouatier (Fr). Mafumeira, poilão, mufuma, árvore da sumaúma, kapoc (Po). Msufi (Sw).

Origin and geographic distribution *Ceiba pentandra* originated in the American tropics. Its natural distribution has been obscured by its widespread introduction after about 1500. Although it has been described as introduced by humans in tropical Africa, there is no historical evidence of such introduction, and there is strong ecological, botanical and cytological evidence that the tree is native to western and central Africa. The dispersal mechanism by which the tree may have crossed the Atlantic Ocean is uncertain, but the fruits float and might have been transported by ocean currents. It has been argued that the tree was domesticated in West Africa, from where it spread to East Africa and Asia. It is now cultivated all over the tropics, but mainly in South-



Ceiba pentandra – wild and planted

East Asia, especially in Indonesia and Thailand. In tropical Africa the tree appears to be native from Cape Verde eastwards to Chad and southwards to Angola. In addition, there are records of the species in 13 other countries in East and southern Africa (including South Africa) and the Indian Ocean islands, but the tree has probably been planted in all other tropical African countries as well.

Uses *Ceiba pentandra* has two main uses, being an important source of fibre and of timber. Historically it has been most important as a source of kapok fibre, the floss derived from the inner fruit wall. Kapok fibre is used for stuffing cushions, pillows and mattresses, and for insulation, absorbent material and tinder. The use of kapok fibre declined in the late 20th century after the introduction of synthetic substitutes. However, there is a renewed interest in the potential of kapok, using new processing techniques, especially in textile applications. The fibre may also have potential as a biodegradable alternative to synthetic oil-sorbent materials, due to its hydrophobic-oleophilic properties.

Currently, the main use of *Ceiba pentandra* is as a source of timber. The wood (trade names: 'fuma', 'ceiba') is mostly used in plywood manufacturing, but also for making boxes and crates, and for lightweight joinery. Traditionally, entire trunks are hollowed out as dugout canoes, and the wood is used for lightweight furniture, utensils, containers, musical instruments, mortars, carvings and similar items. It is suitable for insulation, wooden sandals, heels, rafts, floats, lifeboats, models, insulation and particle board. The buttresses are made into doors, table tops, plates and trays.

The wood is suitable for papermaking. Although it has been recorded to be used as fuelwood in DR Congo, it is not considered very suitable as such, because it only smoulders. The wood can be used for fumigating huts or clothes. Wood ash is used as kitchen salt and for soap making. The bark is used for making hut walls and doors and yields a gum and a reddish brown dye. The leaves and shoots are fodder for goats, sheep and cattle. The leaves, flowers and young fruits are eaten cooked into sauces. The flowers are visited by bees, producing an amber-coloured honey with a characteristic taste. Ash from the fruits is locally made into snuff.

A use that has attracted commercial interest is as a source of seed oil, which has been used in soap, and pharmaceutical manufacturing. The oil can also be used for illumination, paint manufacturing and lubrication. It has been used for culinary purposes, but this is not advisable for health reasons. The seed cake is good as feed or as fertilizer. The seeds are eaten roasted or they are pounded and ground into meal or cooked in soup. They are, however, said to upset the digestion.

Ceiba pentandra finds wide application in African traditional medicine. The root forms part of preparations to treat leprosy. Pulverized roots and root decoctions are taken against diarrhoea and dysentery. Root decoctions are oxytocic. Macerations of the root bark are drunk against dysmenorrhoea and hypertension. The root and stem barks are credited with emetic and antispasmodic properties. Stem bark decoctions are used in mouth washes for treating toothache and mouth problems, and are taken to treat stomach problems, diarrhoea, hernia, gonorrhoea, heart trouble, oedema, fever, asthma and rickets; they are also applied on swollen fingers, wounds, sores, furuncles and leprous macules. Bark extracts are considered emetic; they are drunk or applied as an enema. Macerations of the bark are a cure for heart trouble and hypertension, and are credited with stimulant and anthelminthic properties. The powdered bark is applied on wounds. Gum from the bark is an astringent and is used to treat diarrhoea and as an abortifacient. The leaves are credited with emollient and sedative properties. They are used against scabies, diarrhoea, fatigue and lumbago, and as an alterative, laxative and abortifacient. Young leaves are warmed and mixed with palm oil to be eaten against heart problems. Pounded leaves are applied as a dressing on sores, tumours, abscesses and whitlows. Leaf sap is applied on skin infections, and drunk to treat mental illness. Leaf macerations are drunk or used in baths against general fatigue, stiffness of the limbs, headache and bleeding of pregnant women. Leaf preparations are used as an eyebath to remove foreign bodies from the eye. A decoction of the leaves is applied to treat conjunctivitis and wounds in the eye, and is used for bathing and massage to treat fever. In veterinary medicine a decoction of the leaves is given to treat trypanosomiasis. The flowers are taken to treat constipation, and flowers and fruits are credited with emollient properties. The powdered fruit is taken with water against intestinal parasites and stomach-ache. Kapok fibre is used for cleaning wounds. The seed oil is rubbed in for treatment of rheumatism and applied to heal wounds.

Ceiba pentandra is planted as a wayside and shade tree. The tree is sometimes left by farmers after clearing the forest for agricultural land, to serve as a shade tree for cultivation of crops such as coffee and tea. It is increasingly planted as an ornamental in subtropical areas. The kapok tree has sacred significance for local peoples in many parts of the world, including tropical Africa, where it often serves as a tree under which meetings are held.

Production and international trade Kapok fibre was an important commercial fibre before the Second World War, with Indonesia being the most important producer. After the Second World War, Indonesian production decreased and Thailand became the main producer, but later Indonesian kapok production increased again from less than 30,000 t per year in the 1960s to about 100,000 t per year in 2004–2008, whereas the annual kapok production in Thailand remained stable at 40,000–45,000 t, according to FAO statistics. Most of the kapok produced is not exported.

In tropical Africa production and trade of *Ceiba pentandra* historically has centred on the kapok fibre. In the early 20th century, colonial foresters planted the tree widely in West Africa, as well as in East and southern Africa. Plantings were generally made along roads, providing the benefit of shade in addition to fibre production, and only a few orchards were planted for fibre production, e.g. in Côte d'Ivoire, Burkina Faso and Ghana. During the mid-1900s, kapok was a valuable export product for many West African countries, but its importance declined from the 1960s onwards. Currently, production and trade centres on the timber, mainly for plywood production. Plywood manufacturing in Africa expanded from the 1960s as several countries pursued import substitution, and as world demand for plywood increased rapidly. Commercial use of *Ceiba pentandra* timber has risen with the decline of more valuable species. Exploitation relies almost entirely on naturally occurring trees, although recently efforts have been made to establish plantations in Ghana. In both Ghana and Nigeria *Ceiba pentandra* is considered a 'lesser-known' or 'lesser-used' species, and its future use is expected to increase. The wood has a relatively low value in international markets, but it is an important export product for several African countries. According to ITTO statistics Ghana exported 61,000 m^3 *Ceiba pentandra* plywood in 2003, at an average price of US$ 293/m^3, 54,000 m^3 in 2004, at an average price of US$ 292/m^3, and 37,000 m^3 in 2005, at an average price of US$ 301/m^3. Ghana exported comparable volumes of *Ceiba pentandra* veneer during these years: 62,000 m^3 at an average price of US$ 242/m^3 in 2003, 52,000 m^3 at an average price of US$ 271/m^3 in 2004, and 48,000 m^3 at an average price of US$ 274/m^3 in 2005. In 2005 the average price of *Ceiba pentandra* logs in international markets was US$ 156/m^3, while the export price of sawn wood from Ghana was US$ 246/m^3. 'Ceiba' was by far the least expensive veneer for plywood exterior and core stock in Ghana in 2005. In 2006 it accounted for 19.6% of Ghana's timber exports, the largest percentage of any of the 87 species exported that year. Local and national markets for *Ceiba pentandra* timber are weak; the average log price in Ghana's domestic market was US$ 31–55/m^3 in 2005, while the average sawn wood price was US$ 53/m^3.

Properties The wood is creamy white, streaked with yellow, brown, pink, and/or grey, but discoloration due to fungal attack is extremely common; the heartwood is not clearly demarcated from the sapwood. The grain is interlocked, sometimes irregular, the texture coarse. Growth rings are prominent. The silica content is low.

The wood is lightweight, with a density of (200–)240–380(–450) kg/m^3 at 12% moisture content. The density of the wood increases strongly from pith to bark, and varies between trees from different sites. The wood seasons rapidly, with only slight risks of cupping, springing, twisting or bending. The rates of shrinkage from green to oven dry are 2.5–3.5% radial and 3.9–6.7(–9.1)% tangential. The dried wood is stable in service, making it ideal for plywood core stock.

The wood is particularly weak and soft. At 12% moisture content, the modulus of rupture is 26–61 N/mm^2, modulus of elasticity 2300–5600 N/mm^2, compression parallel to grain 14–26 N/mm^2, shear 2–4 N/mm^2, cleavage 4–13 N/mm, Janka side hardness 1060–1110 N, Janka end hardness 1820–1960 N and Chalais-Meudon side hardness 0.4–1.0. The wood is brittle when dry.

The wood is difficult to saw cleanly and finish smoothly. Sawn surfaces tend to be woolly, and sharp cutters are necessary to achieve a smooth, finished surface. The blunting effect on cutting edges is low. Shaping, boring, turning and mortising often tear the grain, but planing and sanding produce fine results. The wood holds nails and screws poorly, and must be glued for fastening. Fresh logs, if free of insects and fungal decay, are easy to peel into sheets for plywood manufacturing. The wood can be glued satisfactorily and takes paint very well. It has been recorded to cause itching in workers handling it.

The wood has very low durability, being liable to attacks by insects and fungi. It is amongst the most vulnerable African timbers to termites, *Lyctus* beetles, and other boring insects. It is susceptible to white-rot and blue-stain fungi, but resistant to very resistant against brown rot. The wood is extremely vulnerable to decay when in contact with the soil. It readily absorbs preservatives: both vacuum-pressure and open tank systems give good penetration and absorption.

The wood contains cellulose 39%, pentosans 18%, lignin 24% and ash 4%. The solubility in alcohol-benzene is 2.7%, in hot water 8.8%. The wood fibre cells are 2 mm long and 30–35 μm wide. Pulp yields are low.

The total dry matter of ripe fruits, by weight, is composed of 48% shell, 21% fibre, 25% seed and 6% placenta. Kapok fibre cells are (8–)19–22(–35) mm long and (10–)19–20(–30) μm wide, smooth, transparent, cylindrical, with a wide lumen and thin walls. Kapok fibre contains about 43% α-cellulose, 32% hemicellulose, 13–15% lignin and 1% ash. It is resilient, elastic, light (8 times lighter than cotton), water-repellent and buoyant (5 times more than cork). In an uncompressed state, it can support 20–30 times its own weight in water, because when the fibre is immersed in water, the lumen only partly fills with water and contains many air bubbles. Kapok fibre has a low thermal conductivity and very good sound-absorbing properties. A disadvantage is its high inflammability, but techniques have been developed to make it non-flammable. In its natural form, kapok fibre cannot be spun, because of the smoothness of the outer surface. However, techniques have been developed to make spinning possible. The fibre is long-lasting and is not attacked by fungi or pests. White-coloured fibre is preferred. Kapok fibre is irritating to the eyes, nose and throat, and workers exposed to kapok dust for long periods may develop chronic bronchitis. People involved in processing of kapok fibre are advised to wear protective masks. Because of the irritant fibres and the spreading root system, the tree is less suitable as shade or wayside tree.

The seeds yield 11–28% oil, with as main fatty acids: palmitic acid (10–16%), stearic acid (2–9%), oleic acid (49–53%) and linoleic acid (26–29%). The oil resembles cotton-seed oil, but does not contain gossypol. It does contain cyclopropenoid fatty acids such as malvalic acid (7–8%) and sterculic acid (3–4%), which cause abnormal physiological reactions in animals. Therefore the consumption of kapok seeds or seed oil should be discouraged, unless the cyclopropenoid acids have been chemically removed. Per 100 g the presscake contains approximately: moisture 14 g, protein 26 g, fat 8 g, carbohydrates 23 g, fibre 23 g and ash 6 g. The K content of the shell is about 3%, and that of the ash 20–23%.

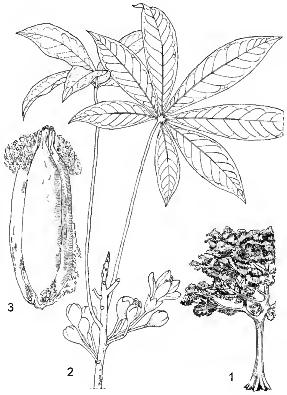
The composition of leaves from Côte d'Ivoire per 100 g dry matter was: energy 486–631 kJ (116–151 kcal), protein 19.1–26.5 g, fat 2.2–2.7 g, carbohydrate 8.0–8.6 g, fibre 55.1–62.8 g, Ca 649–1200 mg, Mg 440–452 mg, Fe 7.0–8.3 mg, carotene 22.7–25.5 mg, riboflavin 0.60–0.73 mg and ascorbic acid 148–250 mg.

A root bark extract has shown in-vivo hypoglycaemic activity in rats. Bark extracts have shown in-vivo and in-vitro anti-inflammatory activity, in-vitro anthelmintic activity, and curare-like activity on anaesthetized cat nerves. Bark decoctions and sesquiterpene lactones isolated from the root bark have shown antimicrobial activity. Leaf extracts have shown in-vitro activity against sickle cell anaemia.

Adulterations and substitutes *Ceiba pentandra* wood is sometimes sold in mixed consignments with that of *Bombax buonopozense* P.Beauv., but the wood of the latter is darker and heavier. Ceiba wood is heavier than balsa (*Ochroma pyramidale* (Cav. ex Lam.) Urb.), but lighter and weaker than obeche (*Triplochiton scleroxylon* K.Schum.). It is not as lustrous as balsa or obeche.

Kapok fibre is obtained from several other African trees, especially *Bombax buonopozense* P.Beauv. and *Bombax costatum* Pellegr. & Vuillet. Fibre obtained from the red silk-cotton tree (*Bombax ceiba* L., synonym: *Bombax malabaricum* DC.) has many of the qualities of that of *Ceiba pentandra*, but is less resilient, has a more brown or yellow colour, and can support only 10–15 times its own weight in water. For industrial purposes kapok fibre has largely been replaced by synthetic products, for instance for the production of life-jackets.

Description Very large, deciduous tree up to 60 m tall, with roots spreading quite horizontally, 10 m or longer, in the upper 40–80 cm of the soil; bole branchless for up to 35 m,



Ceiba pentandra – 1, tree habit; 2, flowering twig; 3, fruit.
Redrawn and adapted by Iskak Syamsudin

straight, usually cylindrical, up to 200(–240) cm in diameter, usually with large plank-like buttresses up to 3(–8) m high extending 1–2 m from the bole; bark surface smooth, pale grey, usually with scattered conical spines 1–1.5 cm long, inner bark pale to pinkish red with vertical stripes of white or yellowish tissue; crown of emergent trees in the forest spreading and umbrella-shaped with no lateral branches lower along the bole, crown of trees in more open vegetation ovoid with lateral branches along much of the bole; branches whorled, dimorphic, branches usually in whorls of 3, horizontal or ascending, older branches often spiny. Leaves alternate, digitately compound, with 5–9(–15) leaflets; stipules linear to narrowly triangular, up to 1 cm long, caducous, leaving scars; petiole (3.5–)5–27 cm long, thickened at base, apex expanded into an almost circular disk; petiolules up to 3 cm long; leaflets sessile, obovate to elliptical, (3.5–)5–21 cm × (1–)2–6.5 cm, cuneate at base, acuminate at apex, entire or sometimes slightly toothed at margin, glabrous, pinnately veined with lateral veins in 7–18(–20) pairs. Inflorescence an axillary fascicle, often on leafless branches, 1–15-flowered. Flowers bisexual, 5-merous, regular, strongly but unpleasantly scented; pedicel 2–5(–8) cm long; calyx campanulate, 9–15 mm × 11–14 mm, lobes rounded to nearly acute, glabrous outside, hairy inside; petals united at base, oblong-spatulate, 22–46 mm × 6–13 mm, pink, creamy yellow or white, hairy outside, glabrous inside; stamens 5–15, united at base in a staminal column, dividing into 5(–6) branches 2.5–5 cm long; ovary semi-inferior, 3–6 mm in diameter, 5-celled, style 2.5–4 cm long. Fruit a pendulous, oblong-ellipsoid capsule 7.5–30(–60) cm × 3–15 cm, dehiscing with 5 valves ('shells') or indehiscent, smooth-valved, brown when ripe, many-seeded. Seeds almost globose, 4–6 mm in diameter, glabrous, dark brown or black, embedded in copious white or greyish floss. Seedling with epigeal germination.

Other botanical information *Ceiba* comprises about 17 species, most of them occurring in tropical America. *Ceiba pentandra* is variable. Sometimes 3 varieties are distinguished:

- var. *caribaea* (DC.) Bakh., occurring in the forests of the American tropics and in West Africa; very large tree up to 70 m tall, with unforked, buttressed and spiny bole and horizontal branches, leaves narrow, flowering irregular, fruits rather short and broad, dehiscent, fibre grey to white; $2n = 80, 88$.
- var. *guineensis* (Schumach. & Thonn.) H.G.Baker, occurring in savanna woodlands of West Africa; small to medium-sized tree up to 18 m tall, bole spineless without buttresses, often forked, branches strongly ascending, leaves broad, flowering annually, fruits elongated and narrow at both ends, dehiscent, fibre grey; $2n = 72$.
- var. *pentandra*, the cultivated kapok of West Africa and Asia; medium-sized tree up to 30 m tall, bole unbranched, usually spineless, buttresses small or absent, branches horizontal or ascending, leaves intermediate between the 2 other varieties, flowering annually after leaf-shedding, fruits short or long, narrowed at both ends or banana-shaped, usually indehiscent, fibre usually white; $2n = 72–84$. It would be more appropriate to classify this variety as a cultivar group.

Anatomy Wood-anatomical description (IAWA hardwood codes):

Growth rings: (1: growth ring boundaries distinct); (2: growth ring boundaries indistinct or absent). Vessels: 5: wood diffuse-porous; 13: simple perforation plates; 22: intervessel pits alternate; 23: shape of alternate pits polygonal; 26: intervessel pits medium (7–10 μm); 27: intervessel pits large (≥ 10 μm); 31: vessel-ray pits with much reduced borders to apparently simple: pits rounded or angular; 35: vessel-ray pits restricted to marginal rows; 43: mean tangential diameter of vessel lumina ≥ 200 μm; 46: ≤ 5 vessels per square millimetre; (47: 5–20 vessels per square millimetre). Tracheids and fibres: 61: fibres with simple to minutely bordered pits; 66: non-septate fibres present; (68: fibres very thin-walled); 69: fibres thin- to thick-walled. Axial parenchyma: 77: axial parenchyma diffuse-in-aggregates; 79: axial parenchyma vasicentric; (86: axial parenchyma in narrow bands or lines up to three cells wide); (89: axial parenchyma in marginal or in seemingly marginal bands); 91: two cells per parenchyma strand; 92: four (3–4) cells per parenchyma strand. Rays: 98: larger rays commonly 4- to 10-seriate; (99: larger rays commonly > 10-seriate); 102: ray height > 1 mm; 106: body ray cells procumbent with one row of upright and/or square marginal cells; 107: body ray cells procumbent with mostly 2–4 rows of upright and/or square marginal cells; 110: sheath cells present; 114: ≤ 4 rays per mm. Storied structure: 120: axial parenchyma and/or vessel elements storied. Mineral inclusions: 136: prismatic crystals present; 137: prismatic crystals in upright and/or square ray cells; (138: prismatic crystals in procumbent ray cells); 141: prismatic crystals in non-chambered axial parenchyma cells.

(P. Mugabi, A.A. Oteng-Amoako & P. Baas)

Growth and development Without any pre-treatment seeds germinate slowly (less than 10% one month after sowing) and germination may continue for 3–4 months. Bush fire may cause simultaneous germination of seeds. Growth is relatively fast. Seedlings planted in Ghana were 29 cm tall 6 weeks after germination, and 63 cm after 51 weeks. The annual increases in height and diameter during the first 10 years are about 1.2 m and 3–4 cm, respectively. In forest gaps height growth may be 2 m/year. The tree is obligately deciduous, losing its leaves for 10–14 weeks in the dry season, and it usually flowers annually in the leafless period. Leafing and flowering periods are more regular in drier parts of the distribution area; in moister areas, leafing and flowering periods are highly irregular. The flowers open at night and are senescent by midday; they are pollinated by bats, but are also visited by moths and bees. The fruits ripen 80–100 days after flowering, the dehiscent types releasing kapok with loosely embedded seeds that are wind-dispersed.

Ecology *Ceiba pentandra* requires abundant rainfall during the vegetative period and a drier period for flowering and fruiting. It thrives at elevations below 500 m, but it grows up to altitudes as high as 4000 m. Night temperatures below 17°C retard germination of the pollen grains, which limits the area in which the trees can be grown for the fruit fibre to latitudes between about 20°N and 20°S, and altitudes below 1500 m. Rainfall should be about 1500 mm per year. In its area of natural distribution, the average annual rainfall is 750–3000 mm. The dry period should not have more than 4 months, and in this period a well-distributed rainfall of 150–300 mm is required. In drier areas, some of the water demand may be met by groundwater. For best results the tree should be planted on deep, permeable soils without waterlogging. The tree is easily damaged by strong winds, and it does not survive fire.

Ceiba pentandra occurs in rainforest, and in gallery forest in drier areas. It is a pioneer in secondary forest and riverine forest, and is rarely found in primary forest. It grows fast in canopy openings caused by disturbance, becoming an emergent in mature stands. In drier parts of its range, the tree is increasingly rare in natural vegetation, but may be abundant in settlements and fields in humid to semi-arid zones. In these settings, it may be planted, or self-sown seedlings may benefit from human protection against livestock and fire. Throughout West Africa, *Ceiba pentandra* is associated with occupied and abandoned settlements.

Propagation and planting *Ceiba pentandra* is usually propagated by seed, although it can also be grown from cuttings. The 1000-seed weight is 20–100 g. The seeds are easily separated from the fruit floss, in which they are loosely held, by shaking dehiscent fruits in a bag. Seeds may be stored up to one year in glass or plastic containers at 4°C and 60% relative humidity. Long-term seed storage has not proven successful, because the seed oil goes rancid. Fresh seeds have germination rates of 90–100% within 3–5 days after sowing, when pre-treated by scoring lightly and soaking in water for 24 hours or by soaking in boiling water for 5 minutes. Germination is good in sandy soil with temperatures of 20–30°C. When the young plants are 12–15 cm tall, they can be exposed to full sunlight. *Ceiba pentandra* is light-demanding, and growth is spindly and poor and mortality is high for seedlings and saplings in shaded locations, including small canopy gaps that close relatively quickly. Young plants can be grown in a nursery and be transplanted into the field when they are 4–10 months old. It is recommended, however, to sow directly on land which has been properly cleared for planting. *Ceiba pentandra* is easily propagated from cuttings, which should be taken from orthotropic branches. Trees raised from seeds root deeper than those raised from cuttings, but develop slower.

Recommended planting distances are 4.5–5 m × 4.5–5 m, with elimination of every second row after 6 years, to arrive at a spacing of 10 m between rows. Seeds may also be sown at about 7 m spacing between trees, with an understorey of crops until the canopy closes, about 5 years after planting. In the first 2 years after planting, vegetation must be cleared periodically around saplings. General tending may be necessary in the following years, by cutting climbers and lianas, and removing dead and diseased trees. Plantations need not be thinned if planted with 7 m spacing unless intercropped with smaller tree crops.

Management *Ceiba pentandra* requires little attention, but the soil must be occasionally weeded and loosened. Fertilizers are not usually applied and there is no information on fertilizer experiments. Pruning is not required. The tree performs best in locations where the vegetation is actively managed to maintain sunny conditions and to reduce climber burden on the trees. Coppicing, pollarding and lopping is possible.

In forests in Ghana the number of trees with a diameter above 90 cm is about 35 per km². In natural forests in Côte d'Ivoire and Cameroon average standing volumes of 6–8 m³/ha have been measured, in Gabon standing volumes were only 0.2–0.6 m³/ha.

Diseases and pests High seedling and sapling mortality may occur in humid climates as a result of leaf spot, dieback, damping off and anthracnose. These infections are caused by various fungal pathogens. Tests have shown that leaf spot and anthracnose are caused by *Colletotrichum capsici*, whereas *Fusarium solani* and *Lasiodiplodia theobromae* were associated with dieback of stem. The most effective fungicides for preventing these infections are Kocide (Cu-hydroxide, at 6.6 g/l) and Aliette (Aluminum tris(ethyl phosphite), at 5 g/l), although these fungicides retard the growth of seedlings. *Ceiba pentandra* is a host tree of Cacao Swollen Shoot Virus (CSSV) causing swollen shoot disease in cocoa, a disease which has had a devastating effect on cocoa production in Ghana and neighbouring countries. *Ceiba pentandra* itself shows considerable resistance.

Harvesting The tree is usually felled above its buttresses, which may necessitate the construction of platforms. To obtain kapok fibre, the fruits are harvested when fully ripe and, in dehiscent types, before they open. Ripeness is indicated by the fruit colour changing from green to brown and the surface possibly becoming wrinkled. The fruits are normally harvested by knocking them off the tree before. Trees normally start to bear fruit when they are 3–8 years old.

Yield A tree 70 cm in diameter above the buttresses yields on average 4 m³ of timber, and trees 100 and 150 cm in diameter above the buttresses 9.3 m³ and 23 m³, respectively.

Under optimum conditions a full-grown plantation tree may yield 330–400 fruits per year, giving 15–18 kg fibre and about 30 kg seed. A satisfactory average annual fibre yield is about 450 kg/ha, whereas about 700 kg/ha is considered very good.

Handling after harvest After the trees have been felled, the wood is liable to attacks by insects and fungi, and logs must be treated with preservatives, extracted, sawn and dried as soon as possible.

To obtain kapok fibre, fruits are hulled as soon as possible after harvesting. Drying is carried out in dry air or with fans in cage-like structures. The seeds lie loose in the floss, and therefore de-seeding is easy. They are usually separated from the floss by beating. The quality of kapok fibre is judged by fibre length, freedom from seeds and foreign matter, moisture content, colour, smell and lustre. Excessive pressure should not be used when kapok is baled for export as it is likely to destroy the elasticity and diminish the quality of the fibre.

Genetic resources In view of its pantropical distribution, *Ceiba pentandra* does not seem to be threatened with genetic erosion. The tree is traditionally protected in many parts of Africa, and is legally protected in several countries, especially in drier parts of its range. However, commercial timber harvesting of *Ceiba pentandra* is considered unsustainable in some areas, including Côte d'Ivoire and Ghana. The largest kapok germplasm collection is kept at the Indonesian Tobacco and Fibre Crops Research Institute in Malang (Indonesia) and contains 180 accessions. Some accessions are held at CNSF (Centre National de

Semences Forestières) in Ouagadougou (Burkina Faso).

Breeding Some work has been done on the selection and propagation of trees with white floss, indehiscent pods and lacking spines. Microsatellite markers have been developed and characterized, providing a tool for rapidly generating information on patterns of genetic variation, gene flow and mating systems.

Prospects Timber industries in Africa have become increasingly reliant upon *Ceiba pentandra* in recent decades, and use of the tree will probably intensify in the near future as many African nations have shifted toward less valuable, historically underutilized species. While *Ceiba pentandra* has clear value in plywood manufacture, increased rates of harvesting should not be accepted uncritically for two main reasons. First, although the use of kapok fibre has declined in recent decades, this resource has high potential as new processing techniques are being developed. Use of the tree as timber should not preclude development of improved fibre industries. Second, in the long term natural regeneration may be insufficient to sustain increased use as a source of timber, while minimal efforts have been undertaken to develop plantations in tropical Africa.

Major references Baker, 1965; Bolza & Keating, 1972; Burkill, 1985; Chudnoff, 1980; CIRAD Forestry Department, 2003; CTFT, 1975; FAO, 2011; Gibbs & Semir, 2003; Sahid & Zeven, 2003; Takahashi, 1978; Voorhoeve, 1979.

Other references Alvarado, Alvarado & Mendoza, 2002; Apetorgbor, Siaw & Gyimah, 2003; Attah, 2005; Beentje, 1989; Beentje & Smith, 2001; Brondani et al., 2003; Fortin & Poliquin, 1976; Herzog, Farah & Amado, 1993; InsideWood, undated; ITTO, 2001; Lamprecht, 1989; Lim & Huang, 2007; Mpiana et al., 2007; Neuwinger, 2000; OT Africa Line, 2007; Poorter et al., 2004; Rendle, 1969; Roussel, 1995; Toledo-Aceves & Swaine, 2007; Wiemann & Williamson, 1989; World Agroforestry Centre, undated.

Sources of illustration Beentje, 1989; Sahid & Zeven, 2003.

Authors C.S. Duvall

CERCESTIS AFZELII Schott

Protologue Oesterr. Bot. Wochenbl. 7: 414 (1857).

Family Araceae

Chromosome number $2n = 42$ (hexaploid)

Synonyms *Cercestis scaber* A.Chev. (1920).

Origin and geographic distribution *Cercestis afzelii* occurs from Senegal eastward to southern Nigeria.

Uses The long and strong stems are used in construction, woven into mats, baskets and fishing nets and are used to tie drums. Preparations from the plant are taken as purgative and against excessive sensitivity to stimulation of the heart. In Senegal the leaves are applied to burns. In central Ghana the ground stem mixed with water is drunk against gonorrhoea.

Production and international trade *Cercestis afzelii* is only traded locally.

Properties Extracts from the leaves showed bacteriostatic activity against *Staphylococcus aureus* and *Enterococcus faecalis* and some activity against the fungi *Candida albicans* and *Cladosporium cucumerinum*. The plant also has analgesic or sedative properties. The leaves contain saponins.

Botany Liana up to 17 m long, climbing by flagella: whiplike organs derived from inflorescences and bearing adventitious feeder roots and sometimes reflexed spines. Leaves simple; petiole up to 20 cm long; leaf sheath short; blade hastate, 20–30 cm long, apical lobe elliptical to ovate, acuminate, basal lobes variable, ovate or lanceolate-elliptical, up to 20 cm long, acute or obtuse. Inflorescence a spadix 5–6 cm long, basal part female, covering ⅓–½ of the axis, apical part male, covering ½–⅔ and creamy white; spathe 5–7 cm long, cylindrical, dark green with red dots; peduncle 3–4 cm long. Flowers naked, unisexual; male flowers with stamens in groups of 4–5, anthers nearly sessile; female flowers purple, ovary globose or ellipsoid, 1-locular, stigma discoid, large, translucent white. Fruit a red, ellipsoid berry up to 2 cm in diameter. Seed globose to triangular.

Cercestis comprises 13 species and is restricted to tropical Africa, from Gambia and Senegal to Uganda and Angola.

Ecology *Cercestis afzelii* occurs in open places in secondary forest.

Management *Cercestis afzelii* is only collected from the wild.

Genetic resources and breeding *Cercestis afzelii* has a large area of distribution and occurs in secondary vegetation; there are no indications that it is threatened with genetic erosion.

Prospects *Cercestis afzelii* will probably remain of occasional and local importance only.

Major references Brown, 2000; Burkill, 1985; Burkill, 2000; Hepper, 1968b; Knecht, 1983.

Other references Addo-Fordjour et al., 2008; Atindehou et al., 2002; Bogner & Knecht, 1995; Jongkind, 2007; Tra Bi, Kouamé & Traoré, 2005.

Authors L.P.A. Oyen

CISSUS QUADRANGULARIS L.

Protologue Syst. nat. ed. 12, 2: 124 (1767).

Family Vitaceae

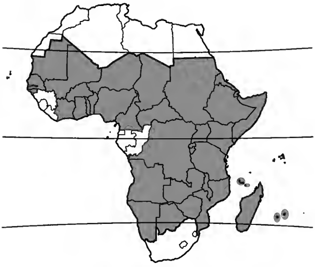
Chromosome number $2n = 24$

Synonyms *Vitis quadrangularis* (L.) Wall. ex Wight & Arn. (1834), *Cissus fischeri* Gilg (1895).

Vernacular names Edible stemmed vine, cactus vine, bone setter, climbing cactus, kangaroo vine, succulent-stemmed wild grape, veld grape, winged treebine, adamant creeper (En). Vigne de Bakel, cissus de Galam, raisin de Galam, vanille du Docteur Burke (Fr). Mbugunyama (Sw).

Origin and geographic distribution *Cissus quadrangularis* is distributed throughout tropical Africa and is only absent in a few countries of West and Central Africa where rainfall is too high. It is also absent from Cape Verde and the Seychelles. Outside Africa it occurs naturally in Arabia, India and Sri Lanka, and it is naturalized in Thailand, Vietnam, Indonesia and the Philippines. In temperate regions it is grown as a potplant.

Uses Strong fibres are extracted from the stems of *Cissus quadrangularis* in Kenya and India. The fibres from the roots are even stronger. The fibres are used in East Africa for wound dressing.



Cissus quadrangularis – wild

The young shoots and leaves are pleasantly acid in taste and eaten as a vegetable, often mixed with other vegetables. Young stems are eaten in Guinea, Sudan and Madagascar. In India, Sri Lanka and Malaysia the green stems are fried or curried and the ash of the plant is used as a baking powder. In Côte d'Ivoire the seeds are eaten cooked.

Cultivation as an garden ornamental is common and in temperate regions it is grown as a pot plant. It is also used as a live fence and in Somalia it is planted to stabilize dunes.

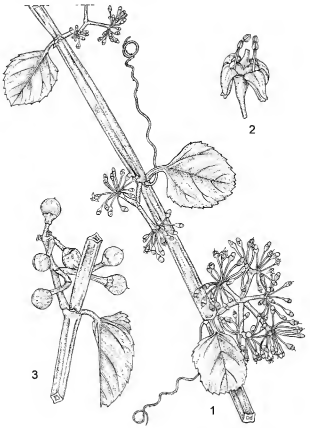
Throughout its range the stems and leaves are used for skin troubles such as wounds, burns and ulcers. In Ayurvedic medicine it is used as an anti-inflammatory and anti-diarrhoeal, and against headache. To treat patients with fever and malaria in Senegal a decoction of the stems and leaves is rubbed into the skin and added to water for washing. In northern Kenya a root infusion is used against chest pain. In East Africa juice from the stem is dripped into the ear against earache. In West and Central Africa an infusion of the leaves is drunk as a cure for sexually transmitted diseases (STDs). In South Africa a decoction of the root is applied for swellings and muscle pain. In Java, Thailand, India and southern Africa juice from the stem is applied for rheumatism and to ease the pain of broken bones and hasten recovery. In India and Indonesia, the powdered root is also used in the treatment of fractured bones, as well as for indigestion. The juice of the plant is applied for scurvy, asthma or nosebleed, and used as an alterative for amenorrhoea. An infusion of the plant is considered purgative. In Thailand, the fresh stem is used in the treatment of haemorrhoids, by swallowing thin slices, covered in banana pulp, without chewing, to prevent irritation in the mouth.

The Turkana of northern Kenya use a root infusion as a pesticide against termites. The Maasai grind the stems in water and wash calves with the liquid as a fly repellent and to kill fleas. In Zimbabwe the pulped whole plant is applied to maggot infested wounds. In India stem and leaf extracts have been successfully applied for the control of leafhoppers and mites. In Guinea stems and leaves are fed to livestock and are supposed to stimulate lactation. However, in Sudan the consumption of *Cissus quadrangularis* by livestock is suspected of causing significant loss of livestock and signs of poisoning were decreased appetite, staggering, dyspnoea, diarrhoea and loss of condition. In Senegal and Central Africa chipped stems and ash of stems are used as fish poison.

Production and international trade *Cissus quadrangularis* is mainly used on a local scale. In Asia capsules containing extracts are produced and marketed for the treatment of hemorrhoids.
As an Ayurvedic medicine it is for sale through internet in different formulations. Several formulations containing *Cissus quadrangularis* are promoted and sold in the western world through internet as a cure for osteoporosis, obesitas and to bodybuilders for increased muscle building. The justification for these uses needs verification through independent research.

Properties The stem has a pungent smell and taste when crushed. Phytochemical analysis of several parts of *Cissus quadrangularis* has revealed the presence of a variety of compounds. The aerial parts contain calcium oxalate crystals that are responsible for the irritating action on the skin and in the mouth. Young leafy twigs have a very high vitamin C content of c. 0.4%. In-vivo laboratory tests have confirmed the validity of the traditional use for the treatment of pain and inflammation associated with hemorrhoids and to reduce the size of hemorrhoids. Intramuscular administration of an extract to rats and use as an ointment in dogs increased the speed of fracture healing. The increased speed of healing is attributed to a potent anabolic steroid. The steroid also has androgenic properties and produces a weight increase. A methanol extract was tested in vivo and in vitro and it exhibited antioxidant activity and acted against liver-tissue damage.

Description Perennial deciduous trailing or climbing herb with tuberous rootstock; stems quadrangular, almost winged, stout, succulent, glabrous, 1–2(–8) m × 1–1.5 cm, constricted at the nodes; tendrils leaf-opposed, simple. Leaves alternate, simple or sometimes palmately 3–5-lobed; stipules ovate, up to 5 mm long; petiole 5–11 mm long; blade somewhat fleshy, ovate or broadly ovate, 1.5–10 cm × 1–11 cm, base truncate, apex rounded, margin serrate. Inflorescence a leaf-opposed cyme, subumbellate, more or less asymmetrical, (2–)4–10 cm × 5–6 cm, peduncle 1–20(–35) mm long, primary branches 2–5, one sometimes further branched, each branch few–15-flowered. Flowers bisexual, 4-merous, sweetly-scented, petals about 2.5 mm long, recurved at anthesis, quickly caducous, pinkish inside, green and red outside. Fruit a rounded, fleshy berry up to 12 mm in diameter, yellow to red or violet, calyx and style persistent, 1-seeded. Seed compressed-elliptical, 5–9 mm long. Seedling with epigeal germination.



Cissus quadrangularis – 1, flowering stem; 2, flower; 3, infructescence.
Source: PROSEA

Other botanical information There is a lot of variation in morphological characteristics of *Cissus quadrangularis*. It is one of a number of closely related species within the genus *Cissus*. For East Africa a review has resolved most of the confusion in this group but for southern Africa confusion persists. Two closely related species, *Cissus cactiformis* Gilg and *Cissus quinquangularis* Chiov., are sometimes considered conspecific with *Cissus quadrangularis*. Identification is often difficult and uses for this species from Guinea, Gabon and Congo, countries that are probably too humid and where it has not been positively recorded, must be attributed to another species. Likewise, characteristics recorded that are contradicting can possibly be real and the result of ecological or physiological conditions. However, mistaken identification is likely as well, as in the case of contradicting statements that the species is very poisonous versus harmless. The genus

Cissus is closely related to *Cyphostemma* and comprises about 200 species. It is found all over the tropics and subtropics. Many *Cissus* species are used in traditional medicine in tropical Africa, Asia, South America and in the Caribbean. *Cissus rotundifolia* (Forssk.) Vahl is a climber with 4–5-angled stems. It is distributed from Eritrea southwards extending into South Africa and occurs wild as well in several Indian Ocean Islands and in the Near East. It has been introduced in the Seychelles. In East Africa the bark is made into rope. In East Africa and in Madagascar the fruits are eaten. Medicinal uses are recorded from Kenya, Uganda and Tanzania. Sap from the stems is rubbed in burns, sap from the tubers is applied to wounds to repel flies and the leaves are used as wound-dressing. Pounded leaves mixed with oil are applied externally to inflammations and to swellings like those caused by bee stings. A leaf decoction is used to cure stomach-ache and diarrhoea. Juice from the pounded leaves is used as eardrops to cure ear infections and is drunk for cardiac problems, dizziness and fainting. The roots serve as a purgative, toothache remedy and are applied externally to cure ulcers.

Growth and development *Cissus quadrangularis* flowers during the rainy season. During the dry season the leaves are shed. It can grow vigorously and cover trees and shrubs entirely. It follows the Crassulacean Acid Metabolism (CAM) pathway, minimizing water loss by fixing CO_2 at night and photosynthesize with the stomata closed during the day. When grown as an ornamental potplant in temperate regions, lowering the temperature to 8–15°C and stopping watering for a few months is beneficial.

Ecology *Cissus quadrangularis* occurs in savannas in arid and semi-arid conditions, from sea-level up to 2000 m altitude.

Propagation and planting *Cissus quadrangularis* can be propagated with stem cuttings but for large scale multiplication seeds are more appropriate. Cuttings are made of 3 internodes, they are left to dry for a few days and then planted in a sandy substrate.

Harvesting In cultivation harvesting starts at about 2 years after planting. Mature stem parts are collected. Applying manure or fertilizer after each harvest is recommended.

Handling after harvest Harvested stems are cut between the nodes and dried in the shade to preserve the active ingredients.

Genetic resources *Cissus quadrangularis* is not threatened with extinction but the variation is poorly understood and should be studied to be able to take measures to conserve the variation within the species.

Prospects It is likely that the demand for *Cissus quadrangularis* for medicinal use in the international market will increase since it is promoted as a cure for obesitas, osteoporosis and recommended to bodybuilders. These claims should be verified by science and the poisonous nature of the stems needs to be investigated.

Major references Aguilar, 2001a; Arbonnier, 2004; Beentje, 1994b; Oliver-Bever, 1986; Verdcourt, 1993.

Other references Barakat et al., 1985; Deka et al., 1994; Descoings, 1967; Descoings, 1997; Hegnauer, 1973; Jainu & Devi, 2005; Jirikasem et al., 2000; Kokwaro, 1993; Neuwinger, 2000; Oben et al., 2008; Panthonga et al., 2007; Prajapati et al., 2003; Selvaraj & Narayanasamy, 1991; Staugärd (Editor), 1989; Thulin, 1999c; Tra Bi, Kouamé & Traoré, 2005; Vollesen, 1989.

Sources of illustration Aguilar, 2001a.

Authors A.T. Tchinda

CLADIUM MARISCUS (L.) Pohl

Protologue Tent. Fl. Bohem. 1: 32 (1809).

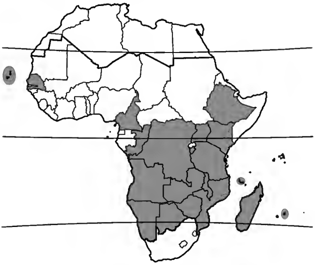
Family Cyperaceae

Chromosome number 2*n* = 36

Synonyms *Cladium jamaicense* Crantz (1766).

Vernacular names Sawgrass, Jamaica sawgrass, swamp sawgrass, fen sedge, great fen sedge (En). Marisque (Fr).

Origin and geographic distribution *Cladi-*



Cladium mariscus – wild

um mariscus is distributed throughout the tropical and temperate regions of the world. In tropical Africa it is recorded from West, Central, East and southern Africa and from the Indian Ocean islands, but it is unclear in which countries exactly.

Uses The stems and leaves are used for thatching. In Uganda, for instance, they are considered excellent material for this purpose. In Hawaii the leaves are used as tying material. In Romania and Malaysia the stems and leaves are used in the manufacture of paper products. The interior portion of the rhizome was traditionally used by indigenous North Americans as surface material for baskets.

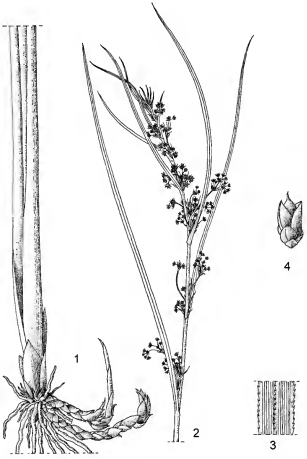
In certain areas of the United Kingdom sawgrass leaves were traditionally harvested for thatching and for fuel. Minor uses of the leaves included covering bricks as they air-dried before kiln-drying, bedding for domestic animals, and strewing on thoroughfares or in public buildings as a temporary floor covering. Drainage channels were filled with sawgrass and covered with topsoil to serve as hollow drains. The plant is unpalatable and offers little nutrition for animals, but in the United Kingdom a mixture of sawgrass and grasses was sometimes cut from mixed-species swamps and fed to animals.

Cladium mariscus swamps are important stores of carbon in the form of deep organic peat soils, originating from years of build-up of decomposing plant litter. *Cladium mariscus* is planted as an ornamental.

Production and international trade Widespread cutting and use of sawgrass leaves is recorded only from the United Kingdom. The standard unit is the bunch, which has a circumference of c. 70 cm upon cutting (this diminishes as the leaves dry), measured where the bunch is tied, 30 cm from the bottom. The leaves in the bunch vary in length with maturity at cutting, though modern thatchers prefer a length of 105 cm.

Properties The flexibility of the leaves makes them a good material for covering the ridges of roofs thatched with other, more rigid materials such as reeds. The seeds contain an alkaloid.

Description Robust, perennial sedge up to 5 m tall, with thick, erect, woody rhizome emitting stolons covered with imbricate scales 2–4 cm long; stems erect, up to 3 m tall, rounded, glabrous, hollow except at the nodes. Leaves inserted at the stem base and along the stem, 3-ranked; sheath tubular, disintegrating into fibres; ligule absent; blade linear, up to 225 cm × 28 mm, apex attenuate, margin sharply serrate. Inflorescence a terminal, compressed panicle (20–)30–90 cm × 5–15 cm, composed of secondary inflorescences inserted at each node in the axil of a long, sheathing bract; secondary inflorescence with numerous clusters of (1–)2–7(–10) spikelets. Spikelets sessile or almost so, lanceolate, ellipsoid or ovoid, 2–6 mm long, pale brown to red-brown, 2(–3)-flowered; glumes 5–7, spirally arranged, ovate, 2–3.5 mm long, obtuse, concave, brown, usually the 3–5 basal ones empty and the next one containing a bisexual flower setting fruit, the uppermost one male; perianth absent; stamens 2(–3); stigmas 2–3. Fruit a broadly ovoid or obovoid nutlet up to 3.5 mm long, apex attenuate, rugulose above, pale brown.



Cladium mariscus – 1, base of stem; 2, upper part of flowering stem; 3, part of leaf; 4, spikelet with fruit.
Redrawn and adapted by Achmad Satiri Nurhaman

Other botanical information Within *Cladium mariscus* various subspecies have been distinguished, but these taxonomic divisions are mainly geographical and the botanical differences are not always clear. The main subspecies are subsp. *mariscus* of Europe and Asia, subsp. *jamaicense* (Crantz) Kükenthal of the Western Hemisphere, Hawaii and Africa, and subsp. *intermedium* Kükenthal of Australia. *Cladium mariscus* subsp. *jamaicense* is sometimes considered a separate species: *Cladium jamaicense* Crantz. Subsp. *mariscus* ('thatching sedge'), occurring in more temperate regions, is a first-class thatching material. A thorough revision of the genus is needed.

Anatomy Air spaces run vertically through the interior of the leaves, separated periodically by horizontal septa. Vascular bundles also run vertically through the leaves, and consist of xylem and phloem surrounded by and separated from one another by fibre bundles. Fibre strands also occur independently running vertically through the leaf.

Growth and development Natural reproduction is principally from rhizomes, which occur 10–20 cm below the surface of seasonally-flooded soils. In permanently-flooded locations sawgrass forms elevated clumps, and rhizomes occur above the sediment surface. Leaf growth is favoured by warm temperatures and occurs at night, as it is inhibited by direct sunlight. Leaves can elongate at rates higher than 15 cm per week under warm conditions with ample moisture. Sawgrass stands produce seed, which is dispersed by water or birds. Seeds have low viability, and seedlings are sensitive to drying-out as well as to flooding. After flowering and seed set, the stem and its associated leaves and rhizome die and decay rapidly. Sometimes shoots never flower, and they continue vegetative growth for years before senescing.

Cladium mariscus is also able to reproduce vegetatively by pseudo-vivipary, i.e. the production on the parent plant of adventitious buds that are capable of development into new individuals in association with floret production in inflorescences. *Cladium mariscus* follows the C_3 photosynthetic pathway.

Ecology *Cladium mariscus* occurs in the margins of lakes, pools, swamps and fens, particularly in sites with good nutrient availability. It usually occurs in shallow freshwater wetlands in warm regions, but it also tolerates brackish water and cool periods. It forms floating mats in deep water. In East Africa it occurs at 1000–2300 m altitude. In southern Africa it occurs in 'dambo' wetlands (natural ecosystems occupying shallow, waterlogged depressions at or near the head of drainage networks). *Cladium mariscus* thrives on deep organic soils that are flooded between 6 and 9 months of the year or longer. The ideal water depth is from 15 cm belowground to 40 cm aboveground. The plant tolerates a pH range of 4.5–8.6. It is a weed of rice fields.

Cladium mariscus is often the dominant species where it occurs, forming monospecific stands. However, when water level or duration of flooding changes, sawgrass is replaced by other species. The same happens with increased inflow of nutrients or brackish water. Sawgrass evolved under conditions of periodic natural fires, which spread quickly through dense sawgrass stands, burning dead litter and living leaves to a uniform height of a few centimetres above water level. Without periodic fire a thick layer of leaf debris builds up, suppressing plant vigour. Sawgrass regenerates rapidly from its rhizomes after fire, because the rhizomes are submerged in water or in contact with moist soil, and hence protected from the intense heat. However, severe fires under dry conditions burn all the way down to the soil and kill rhizomes, in which case regeneration is slow and sawgrass is outcompeted by other successional species. In British sawgrass swamps regular mowing maintained a dense stand of sawgrass, and in the absence of mowing the swamps gave way to other vegetation, namely peat bog or woodland. Conversely, digging peat from sawgrass bogs in Britain was occasionally shown to favour sawgrass, as the species regenerated rapidly in the lowered soil level.

Propagation and planting Swamps of *Cladium mariscus* are natural ecosystems and are not planted. However, sawgrass is sometimes planted as a landscaping plant. In this case, the plant is usually grown from seed, probably because seed is easier to handle and transport than rhizomes and plantlets. The 1000-seed weight is 2.2–2.6 g. Seeds germinate best in soil that is saturated but not inundated, but even under good conditions germination rates of only 30–42% have been recorded. Initial plant growth and survival rates are also better in saturated than in inundated soil.

Management Sawgrass swamps are naturally-occurring, although humans increasingly manage aspects of them. The water table can be maintained at a level to favour *Cladium mariscus*, and prescribed burning or harvesting serves to eliminate plant debris and maintain health of the sawgrass population.

Harvesting In the United Kingdom sawgrass is harvested on a cycle of 3–5 years. More

frequent harvesting leads to a decrease in plant density, whereas longer intervals allow accumulation of dead leaves and growth of woody species. Evidence from the subtropical Florida Everglades indicates that removal of plant matter (in this case by burning) is best done every 3–10 years.
Harvesters must wear heavy clothes to protect their arms, hands, and legs from the sharp sawtooth edges of the leaves. Sawgrass can be harvested at any time of the year, as ground conditions permit, though the United Kingdom it was traditionally harvested in spring or early summer.

Yield Yields from British sawgrass swamps traditionally ranged from 1500–4500 bunches per hectare, cut every four years. In the Florida Everglades the annual aboveground production was estimated at 26 t/ha.

Genetic resources *Cladium mariscus* is distributed widely throughout the world, and its diverse modes of sexual and vegetative propagation ensure that it is at little risk of extinction or genetic erosion. However, local populations of sawgrass may be threatened with genetic erosion or even elimination due to destruction of wetlands. In the case of British sawgrass swamps, decreased use of the plant has led to decreased harvesting of the swamps, which has allowed invasion of the swamps by other species.

Breeding No breeding programmes of *Cladium mariscus* are known to exist.

Prospects Few uses of *Cladium mariscus* are documented for tropical Africa. Its widest expanses are in the subtropical Everglades swamp in the United States, and most recorded uses are from the United Kingdom. The regions of Africa where *Cladium mariscus* is present could benefit by adopting certain British uses of the plant, such as for providing thatching material and fuel. In its areas of occurrence outside of Africa local populations are threatened by the management and mismanagement of the wetlands where they occur. Increased inflows of nutrients and pollutants, cultivation, and wetland drainage and diversion of freshwater sources (which both contribute to encroachment of brackish water from the sea), all alter sawgrass wetland ecosystems drastically, often leading to decreased prevalence of *Cladium mariscus*. These factors may impact African populations of the species.

Major references Burkill, 1985; Clarke, 1901–1902; Hoenselaar, Verdcourt & Beentje, 2010; Hooper & Napper, 1972; Kern, 1974; Simpson & Inglis, 2001; Tucker, 2003; Uchytil, 1992a; Vanden Berghen, 1988.

Other references Bryson & Carter, 2005; Burkill, 2000; Conway, 1936; Conway, 1938; Gordon-Gray et al., 2009; Hsieh & Weber, 1984; Ivey & Richards, 2001; Kaggwa et al., 2001; Lorenzen et al., 2000; Mason, 1988; Miao et al., 1998; Moerman, 1998; Ponzio, Miller & Lee, 1995; Roberts, 1988; Rowell, 1986; Royal Botanic Gardens Kew, 2008a; USDA, NRCS, 2009.

Sources of illustration Kern, 1974.

Authors G. Vaughan

CLAPPERTONIA FICIFOLIA (Willd.) Decne.

Protologue Icon. sel. pl. 5: 1, t. 1. (1846).

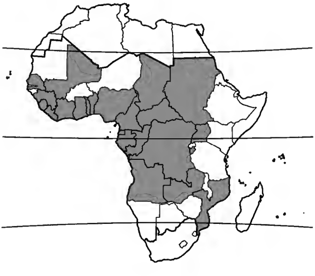
Family Tiliaceae (APG: Malvaceae)

Chromosome number $2n = 36$

Synonyms *Honckenya ficifolia* Willd. (1793).

Origin and geographic distribution *Clappertonia ficifolia* is very widespread in continental tropical Africa. It is introduced and grown as an ornamental in many tropical gardens, for instance in Sri Lanka, Singapore, Borneo, New Guinea, Panama and the southern United States.

Uses *Clappertonia ficifolia* and the bast fibre it produces are known in Cameroon as 'bolo bolo'. The fibre is used for making rope, twine, cordage and mats, nets, hammocks, fish traps and paper pulp. In Cameroon the leafy stems are pounded with water and in this way a slimy liquid is produced that is added to mud and manure. This mixture is smeared on house walls and floors. Beehives made from culms are smeared with the same preparation. The wood



Clappertonia ficifolia – wild

is used for making floats for fishing. In traditional medicine in DR Congo the leaves are used as a cure for liver malfunction. *Clappertonia ficifolia* is widely planted in gardens as an ornamental.

Production and international trade The fibre of *Clappertonia ficifolia* is only used locally, and has not been commercially exploited.

Properties Fibre samples from Sierra Leone and Nigeria investigated around 1900 were stronger than jute. Experiments in Nigeria just after the Second World War also showed that an excellent, very strong fibre can be obtained from the plant. The dry bast of *Clappertonia ficifolia* contains 55% cellulose. Bast fibre from Sierra Leone contained 74% cellulose and 11% lignin. The bark is said to be suitable for paper pulp.

Botany Shrub up to 3 m tall; young branches reddish, with dull yellowish to brownish stellate hairs. Leaves alternate, simple; stipules lanceolate, 8–12 mm long; petiole 0.5–9 mm long, with short and soft hairs; blade usually oblong to ovate, 1–15 cm × 1–12 cm, lower leaves 3–5-lobed, base rounded to subcordate, apex rounded, margin toothed, upper surface green and with stiff hairs or minutely soft hairy, lower surface short soft hairy to densely white hairy, 5–7-veined from the base. Inflorescence a terminal or axillary panicle up to 15 cm long, with 1–3-flowered axillary cymes up to 3.5 cm long; bracts conspicuous, unequal, caducous. Flowers bisexual, regular, 4(–5)-merous; pedicel 5–14 mm long; sepals up to 3.5 cm long, 6 mm wide, pinkish to purplish red; petals round, up to 3 cm × 2 cm, clawed, bright pink, purple or blue-mauve, rarely white; fertile stamens 16, yellow or pink, staminodes numerous; ovary superior, oblong, 4–8-celled, densely yellow-hairy. Fruit a capsule 3–7 cm × 18–25 mm, entirely covered with hairy prickles, each tipped with a bristle, many-seeded. Seeds round, c. 2 mm in diameter, greyish.

Clappertonia comprises 3 species. *Clappertonia ficifolia* is easily distinguished from *Clappertonia polyandra* (K.Schum.) Bech. as the latter has yellow flowers and winged capsules with a line of prickles on the margins of the wings. In Gabon the 2 occur in different altitudinal zones: *Clappertonia ficifolia* is found from sea-level to c. 485 m altitude, and *Clappertonia polyandra* above 460 m altitude.

Ecology *Clappertonia ficifolia* occurs from sea-level up to 1200 m altitude in swamps, riverine and swampy forest, forest fringes and thickets. In fallow land it can become dominant or even form an almost pure, dense stand and these populations are often exploited for fibre production.

Management Propagation is possible by either root cuttings or seeds. Experiments in Nigeria just after the Second World War showed that an excellent fibre could be obtained when the stems of flowering plants were retted for about 28 days.

Genetic resources and breeding *Clappertonia ficifolia* is widespread and behaves as a weed in fallows. Hence, there do not seem to be threats of genetic erosion.

Prospects *Clappertonia ficifolia* is one of the fibre-producing species within the mandate of the International Jute Study Group (formerly the International Jute Organization) together with jute (*Corchorus* spp.), kenaf (*Hibiscus cannabinus* L.), roselle (*Hibiscus sabdariffa* L.) and *Urena lobata* L. Although most research attention is directed to *Corchorus olitorius* L., the prospects for natural fibres are such that attention should be given to *Clappertonia* spp. as well.

Major references Burkill, 2000; Dubois, 1951; Kirby, 1963; Whitehouse et al., 2001; Wilczek, 1963.

Other references Dalziel, 1937; Liu, 2000; Norman, 1937; Nyananyo, 1988; Roecklein & Leung (Editors), 1987; Sosef et al., 2006; Stiles, 1994; Wild, 1963.

Authors C.H. Bosch

CLAPPERTONIA POLYANDRA (K.Schum.) Bech.

Protologue Repert. Spec. Nov. Regni Veg. 28: 58 (1930).

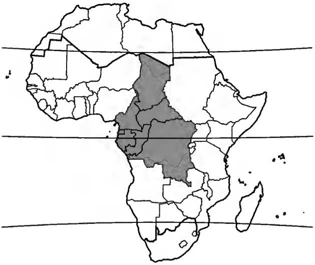
Family Tiliaceae (APG: Malvaceae)

Synonyms *Cephalonema polyandrum* K.Schum. (1900).

Origin and geographic distribution *Clappertonia polyandra* is distributed in Central Africa, from Cameroon to DR Congo.

Uses In DR Congo, where it is known as 'punga', and Gabon the bark fibre is used for making cord, rope and hunting nets. The fibre has also been woven into cloth. A very similar fibre, also known as 'punga', is obtained from *Triumfetta* species. In DR Congo the leaf sap is taken to ease childbirth and a decoction of the roots and leaves is used as a cure for diarrhoea. *Clappertonia polyandra* is planted as an ornamental.

Production and international trade *Clap-*



Clappertonia polyandra – wild

pertonia polyandra is mainly used locally. In DR Congo it has sometimes been an important item of commerce, and around 1950 its fibre was exported, mixed with that from *Urena lobata* L. or *Triumfetta cordifolia* A.Rich.

Properties When properly retted, the fibre strands are long and strong, but compared to Congo jute (*Urena lobata*) they are less soft to the touch, coarser, and inferior in their colour, which is yellow or even brownish when extracted from over-mature stems. Utilisation of the fibre is restricted by its coarseness, but it is suitable for making bags, baling material and twine. The fibre is not particularly resistant to water, and therefore not used for making fishing nets.

Botany Shrub up to 4 m tall; branches sparsely puberulous with stellate hairs, glabrescent. Leaves alternate, simple; stipules lanceolate, c. 6 mm long, caducous; petiole 1.5–17 cm long; blade broadly ovate to suborbicular, 8–20 cm × 5–18 cm, lower leaves 3-lobed, base cordate, with 2 glands, apex acuminate, margin toothed, upper surface reddish and sparsely puberulous, lower surface paler, puberulous and with densely puberulous veins, 5–7-veined from the base. Inflorescence a terminal or axillary panicle up to 30 cm long, with 1–3-flowered axillary cymes, glabrous. Flowers bisexual, regular, 4(–5)-merous; pedicel up to 5 mm long; sepals oblong, c. 2 cm long; petals sessile, oblanceolate, c. 1.5 cm long, yellow; fertile stamens numerous, staminodes numerous; ovary superior, oblong, 5–6-celled. Fruit a capsule 3–5 cm × 1.5–2.5 cm, with 5–7 wings 3–5 mm wide, margin of wings covered with glabrous prickles, many-seeded. Seeds round, c. 2 mm in diameter, brownish.

Clappertonia comprises 3 species. *Clappertonia polyandra* is easily distinguished from *Clappertonia ficifolia* (Willd.) Decne., as the latter has purple, pink or white flowers and non-winged capsules. In Gabon the 2 occur in different altitudinal zones: *Clappertonia ficifolia* is found from sea-level to c. 485 m altitude, and *Clappertonia polyandra* above 460 m altitude.

Ecology *Clappertonia polyandra* occurs in swamps, riverine or swampy forest, and fallow land.

Management Fibre is obtained from wild plants only. Stems are cut when 1–2 m long and as the plants are perennial, they can continuously be harvested for several years. Old, lignified stems and branches should be rejected and only young, green ones are to be used for fibre extraction. Green stems yield 3–4% fibre. When produced at a commercial scale the stems are retted in water before extraction of the fibre. For domestic use, the fresh bark is removed with a knife, cleaned by scraping, dried in the sun, and beaten to separate the fibres. When the fibre ribbons are to be used, they are moistened with water to make them supple. The fibre is made into yarn by rolling it on the thigh.

Genetic resources and breeding As *Clappertonia polyandra* is locally common and behaves as a weed in fallows, the risk of genetic erosion is low.

Prospects *Clappertonia polyandra* is one of the fibre-producing species within the mandate of the International Jute Study Group (formerly the International Jute Organization) together with jute (*Corchorus* spp.), kenaf (*Hibiscus cannabinus* L.), roselle (*Hibiscus sabdariffa* L.) and *Urena lobata*. Although most research attention is directed to *Corchorus olitorius* L., the prospects for natural fibres are such that attention should be given to *Clappertonia* spp. as well.

Major references Dubois, 1951; Kirby, 1963; Wilczek, 1963.

Other references Bouquet, 1969; Burkill, 2000; Chevalier, 1940; Liu, 2000; Missouri Botanical Garden, undated; Parmentier & Müller, 2006.

Authors C.H. Bosch

COCHLOSPERMUM PLANCHONII Hook.f.

Protologue Niger Fl.: 268 (1849).

Family Cochlospermaceae (APG: Bixaceae)

Chromosome number $2n = 12$

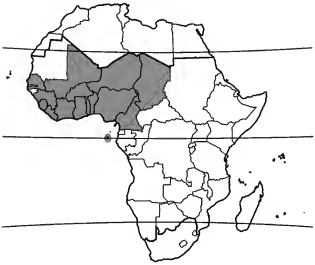
Vernacular names False cotton (En). Faux cotonnier (Fr).

Origin and geographic distribution *Cochlospermum planchonii* is distributed from Senegal eastward to Chad.

Uses The stem bark yields a fibre used in northern Sierra Leone and in northern Nigeria for making string and rope. In Burkina Faso the fibre is used for binding mats. The floss of the fruit can be used for stuffing.

The rootstock is a source of a yellow dye which is used e.g. in Sudan and Nigeria. Hausa people in northern Nigeria add indigo to obtain green shades. In Benin a reddish powder obtained from the rootstock is used as a colouring agent for sauces and soups. In Burkina Faso the flowers are eaten. *Cochlospermum planchonii* is one of the plants preferred by cattle in grazing land in Burkina Faso. In eastern Nigeria the seeds are used as beads.

In traditional medicine in northern Sierra Leone a decoction of the rootstock is drunk for the treatment of gonorrhoea. In Mali the rootstock enters into diuretic preparations and several preparations of the rootstock are prescribed against jaundice. Dried powdered rootstock mixed with shea butter is applied on burn wounds to promote healing. Rootstocks are also rubbed on the body against snake-bites. A decoction of the rootstock or leaves is used as a bath or is drunk against malaria. The powdered rootstock, diluted in water and mixed with lemon juice, is drunk as a tonic. Powdered dried leaves are taken for the treatment of palpitations. Leaf decoctions are drunk or used in washings against fever. A leaf decoction with *Lophira lanceolata* Tiegh. ex Keay and shea butter is taken against jaundice. A tea of the leaves with a few peppercorns is drunk against gastrointestinal problems. In Benin a decoction of the leaves is taken orally against diarrhoea and as antiemetic. Anii and Ifè communities in that country use the leaves for the treatment of dysentery. A decoction of leaves mixed with the bark of *Aphelia africana* Sm. ex Pers. is given against oedema. In Côte d'Ivoire Malinké people use a decoction of leaves as bath or drink against diarrhoea in babies. Traditional healers among the Igede of eastern Nigeria use the plant against AIDS. An extract of the plant is said to control menstruation. A compress of the plant or a wash is applied against broken bones.



Cochlospermum planchonii – wild

Production and international trade *Cochlospermum planchonii* is only used and traded locally. In northern Benin, for instance, products from *Cochlospermum planchonii* are sometimes sold in local markets

Properties Essential oil obtained from the rhizome by hydrodistillation showed in vitro antimalarial activity against *Plasmodium falciparum*. A decoction of the rootstock appeared safe and statistically as efficient as chloroquine for the treatment of uncomplicated *Plasmodium falciparum* malaria in humans, although with slightly slower activity. A methanolic root extract showed potent bioactive activity, including depressant effects on the central nervous system, and analgesic, anti-inflammatory, and antihyperglycaemic effects, with minimal toxicity. Therefore, it seems to have a potential for pharmacological control of pain, inflammation, and diabetes mellitus. An aqueous extract of the rootstock, prepared in the manner used by practitioners of traditional medicine in northern Nigeria to treat jaundice, protects carbon tetrachloride-treated rats from liver damage, as measured by the reduction in serum levels of diagnostic enzymes. Administration of the extract prior to carbon tetrachloride treatment reduced the increase of cytochrome P-450 monoxygenases aminopyrine-N-demethylase and aniline hydroxylase, suggesting hepatoprotection. The inhibitor was identified as zinc formate. The root bark has shown antifungal activity against the plant pathogen *Cladosporium cucumerinum*. The dye extracted from the rootstock has shown antioxidant properties when added to shea butter. The essential oil from the rootstock is rich in 3-tetradecenone and tetradecyl acetate.

Microcrystalline cellulose suitable in pharmaceutical practice to make tablets has been obtained from the lint of the seeds.

Botany Shrub with woody subterranean rootstock from which, in the rainy season, annual, leafy shoots up to 2.5 m tall are produced. Leaves alternate, palmately (3–)5-lobed; stipules subulate, c. 3 mm long; petiole up to 10 cm long; blade in outline 6–15 cm × 7–17 cm, base cordate to cuneate, lobes oblong, basally connate for half to two-thirds of their length, apex rounded, margin entire, rarely dented, upper surface dark green and almost glabrous, lower surface paler and soft-hairy. Inflorescence terminal, with 3–7 fascicled branches, rarely lax; bracts triangular. Flowers bisexual, actinomorphic, 5-merous, 5–9 cm in diameter; sepals unequal, elliptical-oblong to broadly ovate, 8–13 mm × 6–8 mm, the outer 2 shorter than the inner 3, usually velvety; petals obovate, c. 3 cm × 2.5 cm, shallowly emarginate, golden yellow; stamens numerous, filaments 5–15 cm long; ovary superior, globose, style elongate, linear. Fruit a 3–5-valved capsule, ovoid, obovoid or pyriform, 4–7 cm × c. 4 cm, many-seeded. Seeds reniform, 6.5–7 mm × 3.5–4 mm, black, with loosely attached, long, white hairs.

Cochlospermum planchonii flowers towards the end of the rainy season. Fruits are produced 1–2 months after flowering.

Cochlospermaceae is a small family comprising 15 species in 2 genera. *Cochlospermum* comprises 12 species, 5 of these occurring wild in Africa.

Ecology *Cochlospermum planchonii* occurs from sea level up to 1700 m altitude in savanna and forest-savanna mosaic and in fallows, sometimes in hedges. It is a common weed of cultivation, reproducing naturally from seeds and rhizomes. Due to the rootstock plants are tolerant to fire.

Management *Cochlospermum planchonii* is usually collected from the wild, but it is occasionally cultivated by Chamba people of the Shebshi Mountains of eastern Nigeria. Propagation is possible with seeds and rootstock.

To obtain dye, the fresh rootstock is cut and washed, and the bark is removed, after which the remainder is crushed with a pestle and squeezed manually. The resulting liquid is decanted and oven-dried. To obtain food colourant in Benin, the rootstock is cleaned, pounded and dried. Storage of the rootstock, even for only 2 days, may result in breakdown of the compounds responsible for the dye.

The seed hairs are easily separated from the seed coat.

Genetic resources and breeding *Cochlospermum planchonii* is widespread and locally common, but concerns have been expressed about its local vulnerability because of the destructive nature of harvesting rootstocks for medicines or dye.

Prospects *Cochlospermum planchonii* will locally remain an important fibre and dye plant. Its interesting medicinal properties may make it a valuable medicinal plant of much wider importance.

Major references Adjanohoun et al., 1989; Anaga & Oparah, 2009; Burkill, 1985; Nikiema, 2005; Poppendieck, 1980.

Other references Abbiw, 1990; Achigan-Dako et al., 2010; Adjanohoun et al., 1979; Akobundu & Agyakwa, 1998; Aliyu, Okoye & Shier, 1995; Benoit-Vical et al., 2003; Berhaut, 1974; Butare (Editor), 2003; Ohwoavworhua & Adelakun, 2005; SEPASAL, 2010a.

Authors L.P.A. Oyen

COLA GRISEIFLORA De Wild.

Protologue Miss. Ém. Laurent 1: 408 (1907).

Family Sterculiaceae (APG: Malvaceae)

Vernacular names Angongolia (Sw).

Origin and geographic distribution *Cola griseiflora* occurs in Gabon and DR Congo.

Uses The bark is used for tying. The leaf is used as a condiment. The fruit is eaten, and the seed is sucked for the bitter sap. A maceration of the pounded bark is used as a wash to facilitate childbirth. A decoction of the leaf is drunk to strengthen people recovering from any disease.

Botany Medium-sized tree up to 22(–35) m tall; bole up to 30 cm in diameter; outer bark greyish or yellowish grey, longitudinally corrugated; branches glabrous. Leaves alternate, simple and entire; stipules narrowly linear, c. 10 mm long, early caducous, puberulous, margins ciliate; petiole up to 16 cm long, pubescent to glabrous; blade oblong-elliptical, sometimes obovate, 6–30 cm × 2–16 cm, base long-cuneate, apex sharply acuminate, papery or leathery, reddish brown to grey-beige, upper surface glabrous, lower surface sparsely hairy, pinnately veined with 7 pairs of lateral veins. Inflorescence a fascicle, axillary or on older wood; bracts ovate, c. 2 mm long, hairy. Flowers unisexual or bisexual, regular, brownish or greenish white; pedicel slender, 10–29 mm long, jointed below the middle; calyx short campanulate, with calyx tube 1–2 mm long and 5(–6) narrowly oblong lobes 6–7 mm long, outside with short simple hairs mixed with stellate hairs, inside papillose; male flowers with androphore 3–5 mm long, thickened at the base, slender at the top, carrying 1 whorl of 10 thecae; female and bisexual flowers with superior ovary consisting of 3–4 carpels, styles 2–3 mm long. Fruit consisting of follicles; follicles sessile, almost ovoid, 6 cm × 3.5 cm, with a 3–4 mm long beak, stellate hairy, 3–7-seeded. Seeds plano-convex, 20 mm × 15 mm.

Cola comprises about 125 species and is restricted to continental Africa.

Ecology *Cola griseiflora* occurs up to 800 m altitude in half-deciduous or evergreen rainforest, rarely in swamp or gallery forest.

Genetic resources and breeding It is not known whether *Cola griseiflora* is threatened by genetic erosion, but it occurs in habitats which are under pressure in Central Africa.

Prospects *Cola griseiflora* is a local source of tying material, food and traditional medicine. As information on its properties is lacking, it is difficult to assess the prospects of this species, but in view if its limited distribution, it is unlikely to become important.

Major references Germain & Bamps, 1963; Hallé, 1961; Kawukpa & Angoyo, 1994; Nyakabwa, Bola & Vasolene, 1990; Nyakabwa & Dibaluka, 1990.

Other references Brenan, 1979; Cheek & Dorr, 2007; CJB & SANBI, 2009.

Authors M. Brink

COMBRETUM ACULEATUM Vent.

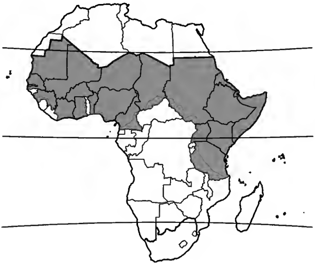
Protologue Choix Pl. t. 58 (1808).

Family Combretaceae

Chromosome number $2n = 26$

Synonyms *Poivrea aculeata* DC. (1828).

Origin and geographic distribution *Combretum aculeatum* is distributed in the Sahelian and Sudano-Sahelian zones from Mauritania and Senegal eastward to Eritrea and from there southward to Uganda and Tanzania. It also occurs in Morocco, Saudi Arabia and Yemen.



Combretum aculeatum – wild

Uses The twigs are used to make donkey panniers and baskets for winnowing or fishing. In Kenya the tough and flexible branches are sought after for making laths in hut building, whereas thicker stems are made into walking sticks. In Chad the twigs are also incorporated in mud walls, and they are used as whips.

Fresh and fallen leaves, fruits and seeds are important as fodder, much appreciated by ruminants. In the Sudanian zone *Combretum aculeatum* is one of the most important sources of browse for small ruminants, which has given the plant the name 'goat's groundnut' in some areas. The wood is a good fuel and source of charcoal; its embers produce heat for a long time without tending. Fulsé people of Burkina Faso limit the use of the wood to roasting sacrificial meat. The leaves and seeds are occasionally eaten, mainly as famine food. *Combretum aculeatum* is sometimes grown as live fence. The flowers are visited by bees.

Various plant parts are used in African traditional medicine. The roots are used as purgative and vermifuge, and for the treatment of wounds, stomach-ache, colic, gonorrhoea, loss of appetite and leprosy. The Soce of Senegal use a root-decoction in the treatment of catarrh. The Serer of Senegal use sap from the centre of the stem to treat eye-troubles. The stem bark is used to heal wounds. In Sudan an extract of the bark, leaves or seed is taken to treat tuberculosis of the skin, or root preparation are applied as a poultice. In Senegal a decoction of the leaves is taken to promote urination in cases of venereal disease and obstruction of the urethra. In Ethiopia the leaves are used as anthelmintic. Branches are used to facilitate teething in children and to treat eye problems. Branches with leaves are applied against dysentery, the leaves also against gonorrhoea. The seed stops hiccup and relieves constipation.

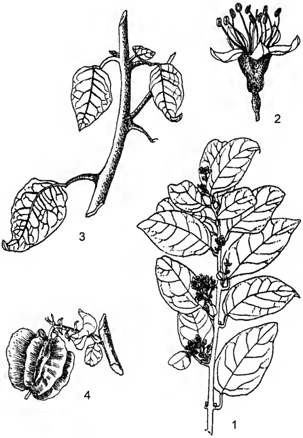
Many medico-magical (against sterility in women and mental problems) and magic or religious (attraction of fish) uses of *Combretum aculeatum* have been reported.

Production and international trade *Combretum aculeatum* is locally traded.

Properties In an analysis in Burkina Faso, the feed composition of *Combretum aculeatum* browse per 100 g dried green leaves (dry matter content 90.7%) was: organic matter 91.0 g, crude protein 16.1 g, neutral detergent fibre 28.5 g, acid detergent fibre 21.7 g, lignin 3.8 g, tannin 6.8 g. An analysis in Niger indicated per 100 g dry matter: crude protein 9.5 g, neutral detergent fibre 33 g, acid detergent fibre 27 g, ash 6 g. In Niger sheep allowed to browse for 1–2 hours per day on *Combretum aculeatum* in addition to standard rations showed reduced feed intake, poorer digestion and reduced live weight gain in comparison with control animals. However, in an experiment in Burkina Faso, sheep and goats fed on sorghum stover responded positively to addition of *Combretum aculeatum* browse. The body weight gain in sheep was nearly double that in goats.

Description Climbing shrub up to 8 m tall or, in the absence of support, a compact or rambling shrub up to 4.5 m tall; young branches grey to rufous pubescent, older shoots with yellow-brown to dark red bark; inner bark greenish or pale yellow. Leaves alternate or subopposite; petiole up to 1.5 cm long, usually persistent and forming recurved spines up to 17(–30) mm long; blade broadly elliptical to obovate, up to 7(–8.5) cm × 5 cm, base cuneate, apex retuse to shortly acuminate, lightly to densely pubescent on both surfaces, lateral veins in 4–6 pairs, rather prominent below. Inflorescence of short axillary racemes c. 2 cm long. Flowers bisexual, 5-merous, fragrant; lower receptacle 4–8 mm long, constricted above and below the ovary, tomentose; upper receptacle urceolate-campanulate, (3–)4–6 mm × 3–4 mm, pubescent; sepals deltate, sometimes attenuate, greenish or red; petals oblanceolate to obovate, 4–8 mm × 1–2 mm, white, lightly pubescent outside; stamens 10, in 2 circles, filaments 4–10 mm long, anthers c. 7 mm long; ovary inferior, style c. 8 mm long. Fruit indehiscent, 5-winged, obovate in outline, up to 27 mm × 23 mm, apex emarginate; body shortly pubescent; wings papery, c. 5 mm wide, purplish and somewhat shiny when young, yellow-brown when ripe; stipe 6–12 mm long. Seed c. 1 cm long, beige-brownish.

Other botanical information *Combretum* is a very large genus, comprising about 250 species distributed worldwide in the tropics and subtropics. About 140 species occur in tropical Africa. *Combretum aculeatum* is sometimes confused with *Combretum acutum* Laws because of its white flowers, but the latter has violet young branches.



Combretum aculeatum – 1, flowering branch; 2, flower; 3, older, spiny branch; 4, fruit.
Redrawn and adapted by Iskak Syamsudin

Growth and development Unlike many other *Combretum* species, *Combretum aculeatum* reproduces readily from seed. Soil moisture has a strong influence on growth and development. Flowering starts at the end of the dry season or the beginning of the rainy season. Water availability and the time and duration of flowering are closely related, and flowering has been recorded to last 40–110 days. Plants may bear flowers and mature fruits simultaneously. The appearance of new leaves seems less closely controlled by the availability of water in the soil.

Ecology *Combretum aculeatum* occurs from sea-level up to 2000 m altitude in areas with an annual rainfall of 250–800 mm, on stony, sandy or clayey soils, sometimes on termite mounds. It occurs in bushland, thickets, wooded grassland with *Acacia* and *Commiphora*, sometimes on slopes or along rivers. It is reported to withstand flooding, but in seasonally flooded areas of Sudan, it is restricted to termite mounds, which are normally above the flood level. *Combretum aculeatum* is browsed by many herbivores but avoided by elephants. The above-ground parts of the plants are susceptible to fire; as a result plants often have annual branches only.

Propagation and planting Propagation from seed in a nursery is possible. Fruits are harvested by shaking fruit bearing branches. Seeds are normally left within the fruit at least until sowing. De-winged fruits are easy to handle and are often used. Seeds are orthodox and store well, although some reports indicate that fresh seeds should be used for planting. The 1000-seed weight is about 60 g. The seeds germinate well, with a germination rate of 60–80%. Seedlings are ready for transplanting after about 3 months. Early growth is vigorous, provided plants are protected from browsing. Vegetative propagation is possible with suckers and rootstock division.

Management *Combretum aculeatum* is generally harvested from natural stands. In Mali it is protected in fields and planted around homesteads as live fence and source of forage. It responds well to coppicing.

Handling after harvest Leaves and fruits are sometimes dried in the sun and stocked for use in the dry season.

Genetic resources *Combretum aculeatum* is widespread and common. There are no indications that it is affected by genetic erosion, although it is locally overgrazed to an extent that regeneration is impaired.

Prospects In many sub-Saharan countries *Combretum aculeatum* is a high-priority species for management and conservation actions. To increase its numbers and productivity, its management in land-use systems deserves more attention. Its easy multiplication makes this species a favourable candidate for planting, for instance in browse hedges in the Sahel and Soudano-Sahel zones. In this respect, forms with rapid growth and high palatability are to be selected.

Major references Arbonnier, 2000; Baumer, 1983; Beentje, 1994b; Bein et al., 1996; Bosma & Bicaba, 1997; Keay, 1954b; Liben, 1983; SEPASAL, 2010b; von Maydell, 1983; Wickens, 1973.

Other references Allegria, Hermans & Minnick, 1986; Anttila, Alakoski-Johansson & Johansson, 1993; Bailly et al., 1982; Bekele-Tesemma, Birnie & Tengnäs, 1993; Boukoungou & de Framond, 1988; Calabrò et al., 2007; Chira & Kinyamario, 2009; Gillet, 1990; Heermans, 1986; Jackson, Taylor & Conde-Wane, 1983; Le Houérou (Editor), 1980; Le Houérou, 1989; Neuwinger, 2000; Orwa et al., 2009; Ruelland, 1988; Sacandé & Pritchard, 2004; Sangaré et al., 2003; Thiombiano, Wittig & Guinko, 2003; Thulin, 1993; Touzeau, 1973.

Sources of illustration Schnell, 1953a.

Authors S. Konsala & G. Todou

COMMIPHORA MULTIJUGA (Hiern) K.Schum.

Protologue Just's Bot. Jahresber. 27, 1: 480 (1901).

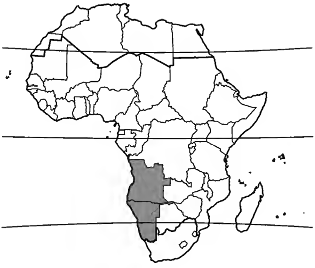
Family Burseraceae

Vernacular names Purple-stem commiphora, purple-stem corkwood (En).

Origin and geographic distribution *Commiphora multijuga* occurs in Namibia, mainly in Kaokoland from the Kunene River southwards to Welwitschia. It is also recorded from Angola.

Uses The twigs have a pleasant taste and are used to clean the teeth. The soft wood is carved into utensils such as spoons, plates, bowls and buckets. The resin and the powdered bark are used as perfume. The leaves are browsed by livestock. *Commiphora multijuga* is a very attractive tree with contrasting bark and delicate leaves, and it has horticultural potential for frost-free areas. The tree has religious significance for local people.

Properties The sticky, colourless resin, which can squirt up to 10 cm high when twigs



Commiphora multijuga – wild

are broken, is very painful when it gets into the eyes and can cause blinding.

Botany Dioecious, deciduous shrub or small tree 3–8 m tall, usually single-stemmed; bark reddish or purplish grey to dark brown, smooth, not peeling but sometimes cracked on old stems; young branchlets sparsely pubescent to pubescent. Leaves spirally arranged, imparipinnately compound, 4–10-jugate, sparsely pubescent or almost glabrous; petiole 1.5–6 cm long, slender; rachis 4–20 cm long; petiolules 0.5–1.5 cm long, slender; leaflets drooping, asymmetrically elliptical, broadly elliptical to almost rotund or diamond-shaped, 1–2.5 cm × 1–2 cm, with terminal leaflet smaller than lateral ones, base acuminate, rounded or square, apex acuminate, margin entire, glabrous, midvein prominent above. Inflorescence consisting of simple or compound dichasial cymes or thyrsoid, up to 5 cm long, glabrous or sparsely pubescent. Flowers unisexual, perigynous, 4-merous, cream-coloured to yellow; pedicel 1–4 mm long, glabrous or sparsely pubescent; calyx glabrous or sparsely pubescent; petals conspicuously recurved; disc 4-lobed, upper part of lobes free but lower part adnate to hypanthium; stamens 8, rudimentary in female flowers; ovary 2-celled, stigma capitate, gynoecium rudimentary in male flowers. Fruit a subglobose drupe c. 15 mm × 15 mm × 14 mm, splitting into 2 valves, glabrous; endocarp hardened, smooth; pseudo-aril red, cupular with 4 arms of equal length reaching almost to the apex of the stone.

The plants are very aromatic. Large quantities of colourless, pungent and sticky resin exude when twigs are cut. Flowering starts in September; it peaks and ends in December. Fruits mature in (December–)March–April. New leaves appear in November and trees are in full leaf from December until March.

Commiphora comprises about 190 species, of which 150 in Africa.

Commiphora virgata Engl. ('slender corkwood', 'twiggy commiphora') is a shrub or small tree up to 3(–5) m tall, also occurring in Angola and Namibia, where it usually grows at altitudes of 400–1000 m on rocky hills or stony slopes, sometimes sympatrically with *Commiphora multijuga*. It has a yellowish white to silvery bark, peeling around the stems in papery strips, and 3-foliolate leaves. It is used similarly to *Commiphora multijuga*. Additionally, decoctions of the leaves, bark and stem are used in traditional medicine for the treatment of cough, colds, stomach disorders, heart and chest pains, and as a tonic, and the roots, bark and twigs are chewed, sometimes after cooking, to aid digestion after eating meat.

Ecology *Commiphora multijuga* occurs at 100–1100 m altitude in hot and arid regions (average annual rainfall 50–450 mm), on hill slopes and rocky outcrops, growing on various rock types. It does not tolerate frost.

Management The plant parts used are only collected from the wild. The 1000-seed weight is about 230 g. The tree can be coppiced.

Genetic resources and breeding *Commiphora multijuga* has a small area of distribution, but is locally common. For genetic erosion, it is classified in the least risk category in Namibia, but is not included in the IUCN Red list.

Prospects *Commiphora multijuga* is likely to remain of minor use only.

Major references Curtis & Mannheimer, 2005; Roux, 2003; SEPASAL, 2010c; van der Walt, 1986; van Wyk & van Wyk, 1997.

Other references Coates Palgrave, 1983; Irish, undated; Liu et al., 2008a; Neuwinger, 2000; Tönsjost, 2007; van Wyk & Gericke, 2000; van Wyk & van Wyk, 2007.

Authors L.P.A. Oyen

CORCHORUS AESTUANS L.

Protologue Syst. nat. ed. 10, 2: 1079 (1759).

Family Tiliaceae (APG: Malvaceae)

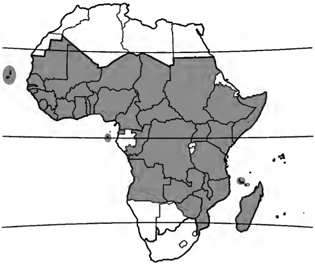
Chromosome number $2n = 14$.

Synonyms *Corchorus acutangulus* Lam. (1786).

Vernacular names West African mallow, East Indian mallow, jute (En). Gombo par terre, gombo rampant, gombo sauvage (Fr). Msafa (Sw).

Origin and geographic distribution *Corchorus aestuans* is a pantropical species, thought by some to originate from the New World tropics in Latin America, by others from the Old World tropics in Africa and South and South-East Asia. It is distributed throughout tropical Africa from Senegal eastward to Somalia and southward to South Africa, and it is locally cultivated.

Uses The stem yields a bast fibre, which can be made into thread and string, but the product is coarser and less durable than that made from *Corchorus capsularis* L. (white jute). The leaves are widely eaten as a vegetable. In northern Benin, for instance, it is consumed as leafy vegetable in a mucilaginous sauce, and its cultivation in the rainy season for household



Corchorus aestuans – wild and planted

consumption has been recorded in south-western Benin. However, the consumption of *Corchorus aestuans* is lower than that of the cultivated *Corchorus olitorius* L. and *Corchorus tridens* L. In some tribes in Africa there are taboos with regard to *Corchorus aestuans*; its consumption is for instance forbidden in Ouatchi communities in Togo. In north-eastern India the root is cooked as a vegetable. The foliage is browsed by all livestock.

In traditional African medicine an extract of the roots or leaves is taken for the treatment of gonorrhoea, and an extract of the whole plant, including the roots, is used for making injections for the treatment of urethral discharges. In DR Congo the leaves are squeezed and the sap is sniffed for the treatment of headache. In India the seeds are used for the treatment of stomach-ache and pneumonia. The medicinal uses in the Philippines are similar to those of *Corchorus capsularis*: the leaves serve against headache, and the seeds, in the form of powder or in decoction, as a tonic, carminative and febrifuge.

Production and international trade The young shoots and leaves, either from cultivated or wild plants, are locally sold. Seedlings are also traded.

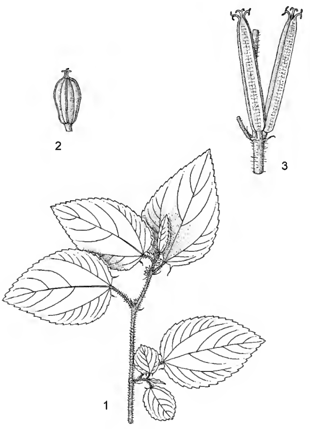
Properties The fibre is good, but its strength is lower than that of *Corchorus capsularis* and *Corchorus olitorius*.

On cooking the leaves exude a large quantity of mucilage, making them very slimy. The seeds contain 22.6% protein and 8.3–12.8% oil. Amino acids in the seed include valine, lysine, serine, aspartic acid, threonine and phenylalanine. The oil contains β-sitosterol and the fatty acids palmitic acid, stearic acid, oleic acid and linolenic acid. The seed also contains corchorine, a glycoside of the strophanthidine group, and quercetine, a flavonoid.

An ethanolic extract of the entire plant was found to have anti-cancer activity against epidermal carcinoma of nasopharynx in tissue culture. Corchorusin D, one of various triterpenoid glycosides isolated from the aerial parts of the plant, has shown anti-leukaemic activity in U937 and HL-60 cell lines.

Adulterations and substitutes In tropical Africa the wild and cultivated species *Corchorus olitorius* and *Corchorus tridens* and the wild species *Corchorus asplenifolius* Burch., *Corchorus fascicularis* Lam. and *Corchorus trilocularis* L. are used in the same way as *Corchorus aestuans*. In tropical Asia *Corchorus olitorius* and *Corchorus capsularis* are the main species used for industrial jute fibre production, and *Corchorus aestuans* is only of secondary importance. Other fibre yielding species such as the cultivated roselle (*Hibiscus sabdariffa* L.), and the wild species *Hibiscus asper* Hook.f. are good substitutes of *Corchorus aestuans* as a source of fibre for households in rural Africa. For vegetable use, all the enumerated *Corchorus* species and okra (*Abelmoschus esculentus* (L.) Moench. and *Abelmoschus caillei* (A.Chev.) Stevels) are substitutes of *Corchorus aestuans*.

Description Prostrate to ascending, annual or perennial herb up to 50(–100) cm tall; stems much branched, pilose, red-brown. Leaves alternate, simple; stipules sharply pointed, up to 1 cm long, pilose; petiole 0.5–3(–5.5) cm long, hairy; blade narrowly to broadly ovate or elliptical, 1.5–9 cm × 1–4.5 cm, base rounded, usually with 2 basal bristles up to 5 mm long, apex acute to rounded, margin toothed, with scattered pubescence mainly on veins, with 4–7 basal veins. Inflorescence an axillary fascicle, 1–3-flowered; peduncle up to 2 mm long; bracts up to 3 mm long, sharply pointed. Flowers bisexual, regular, 5-merous; pedicel up to 3 mm long, sepals free, linear, 3–4 mm long, acuminate; petals free, narrowly obovate or oblanceolate, 3–4 mm long, golden yellow, with a basal claw 0.5 mm long; stamens c. 10, c. 3 mm long; ovary superior, style c. 1 mm long. Fruit a cylindrical capsule 1–4 cm × c. 0.5 cm, solitary or 2–3 together, straight or slightly curved, with wings up to 2 mm wide and 3–5 spreading beaks 1.5–3 mm long at the apex, glabrous, splitting into 3–5 valves, many-seeded. Seeds rhomboid-cylindrical, somewhat angular, 0.5–1



Corchorus aestuans – 1, flowering branch; 2, flower bud; 3, fruits.
Redrawn and adapted by Achmad Satiri Nurhaman

mm long, pitted, brown to black.

Other botanical information The genus *Corchorus* comprises an uncertain number of species, with estimates ranging from 40–100. Evaluation of the genetic diversity in jute species using STMS, ISSR and RAPD markers has shown that wild *Corchurus aestuans* clustered with cultivated *Corchorus olitorius*. This close relationship was confirmed in studies of seed proteins and karyotypes in nine *Corchorus* species. This indicates that *Corchorus aestuans* may be a progenitor of *Corchorus olitorius* cultivars, but it is also possible that both species evolved from a common ancestor. The bark of *Corchorus kirkii* N.E.Br., a shrub up to 2.5 m tall distributed in Botswana, Zimbabwe, Mozambique and South Africa, is recorded to be used for making baskets in Zimbabwe.

Ecology *Corchorus aestuans* occurs from sea-level up to 1350 m altitude in grassland, coastal plains, riverbanks, sandy riverbeds, alluvial depressions and disturbed locations, such as waste places, fallow land and roadsides. It also occurs as a weed in cultivated land.

Propagation and planting Natural reproduction is by seed. The 1000-seed weight is 0.4–0.8 g. Pretreatment of the seed with concentrated sulphuric acid was shown to enhance germination. Seeds have shown orthodox storage behaviour.

Diseases and pests In experiments in India 14 out of 18 *Corchorus aestuans* accessions showed resistance to stem rot caused by the fungus *Macrophomina phaseolina*, the principal pathogen in both *Corchorus capsularis* and *Corchorus olitorius*. These accessions may therefore be useful in interspecific hybridization programmes for the improvement of jute production. The fungus *Alternaria alternata* is reported to cause leaf spot in *Corchorus aestuans* in India.

Harvesting For fibre extraction, uprooting of the plants is common and the stem bark is manually stripped by cracking the lower part of the stem. The fibre is usually used fresh, with no additional processing. Industrial fibre extraction could use the same processes as those used for the commercially produced jute species. For vegetable consumption, fresh shoots are cut, which favours the development of lateral shoots when harvested at regular intervals.

Yield In experiments in India *Corchorus aestuans* accessions from India, China and Tanzania had fibre yields of 1.1–2.3 g per plant, whereas *Corchorus capsularis* and *Corchorus olitorius* had yields of 2.8–15.2 g per plant. This was related to *Corchorus aestuans* plants flowering earlier and remaining smaller.

Genetic resources Because of its wide distribution and its weedy and invasive behaviour, *Corchorus aestuans* is not in danger of genetic erosion. There is rather a need to develop strategies to control its invasive behaviour. *Corchorus aestuans* is among the *Corchorus* species conserved at the National Gene Bank of Kenya in Kikuyu.

Breeding In experiments in the early 1960s interspecific crosses between *Corchorus aestuans* and *Corchorus olitorius*, *Corchorus capsularis* and *Corchorus trilocularis* were not successful. Later, however, hybrids of *Corchorus aestuans* and *Corchorus olitorius* were obtained at the Central Research Institute for Jute and Allied Fibres in Barrackpore (India), and these were superior to *Corchorus olitorius* cv. O-4 with respect to the length of the ultimate fibre cells.

Prospects *Corchorus aestuans* is locally useful as a cheaply available fibre plant and vegetable. As the fibre yield and quality are lower than those of other *Corchorus* species, *Corchorus aestuans* has uncertain prospects for commercial fibre extraction. It could be useful in jute breeding programmes to increase disease resistance and fibre quality in *Corchorus capsularis* and *Corchorus olitorius*.

Major references Akoègninou, van der Burg & van der Maesen, 2006; Burkill, 2000; Keay, 1958h; Mallick et al., 2010; Palve & Sinha, 2005; Palve, Sinha & Mandal, 2004; Roy et al., 2006; Sebsebe Demissew, 1999; Sinha, Mandal & Palve, 2003; Whitehouse et al., 2001.

Other references Achigan-Dako et al., 2010; Ayensu, 1978; Barclay & Earle, 1974; Batawila et al., 2007; Capuron, 1963; Chaudhuri & Jabbar Mia, 1962; Chawan & Sen, 1973; Dixit, Srivastava & Sharma, 1974; Gueye & Diouf, 2007; Irvine, 1961; Islam, Haque & Haque, 1980; Kayang, 2007; Kemei, Wataaru & Seme, 1997; Mahapatra & Saha, 2008; Maity & Datta, 2009; Maity, Datta & Chattopadhyay, 2009; Neuwinger, 2000; Saxena, Jain & Saksena, 1981; Vollesen & Demissew Sebsebe, 1995; Wild, 1963.

Sources of illustration Capuron, 1963.

Authors S. N'danikou & E.G. Achigan-Dako

CORCHORUS OLITORIUS L.

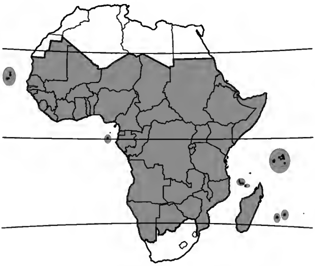
Protologue Sp. pl. 1: 529 (1753).

Family Tiliaceae (APG: Malvaceae)

Chromosome number $2n = 14$

Vernacular names Jew's mallow, jute mallow, krinkrin, tossa jute, bush okra, West African sorrel (En). Corète potagère, jute potager, mauve des Juifs, craincrain, krinkrin (Fr). Coreté, caruru da Bahia (Po). Mlenda (Sw).

Origin and geographic distribution The geographical origin of *Corchorus olitorius* is often disputed, because it has been cultivated since centuries both in Asia and in Africa, and it occurs in the wild in both continents. Some authors consider India or the Indo-Burmese area as the origin of Corchorus olitorius and several other *Corchorus* species. However, the presence in Africa of more wild *Corchorus* species and the larger genetic diversity within *Corchorus olitorius* point to Africa as the first centre of origin of the genus, with a secondary centre of diversity in the Indo-Burmese region. At present *Corchorus olitorius* is widely spread all over the tropics, and it probably occurs in all countries of tropical Africa.



Corchorus olitorius – wild and planted

In tropical Africa it is reported as a wild or cultivated vegetable in many countries. It is a leading leaf vegetable in Côte d'Ivoire, Benin, Nigeria, Cameroon, Sudan, Kenya, Uganda and Zimbabwe. Jew's mallow is also cultivated as a leaf vegetable in the Caribbean, Brazil, India, Bangladesh, China, Japan, Egypt and the Middle East. It is cultivated for jute production in Asia (India, Bangladesh, China) together with *Corchorus capsularis* L., but in Africa it is of no importance as a fibre crop, although the fibre may be used domestically.

Uses Jew's mallow is used as a leafy mucilaginous vegetable. The cooked leaves form a slimy sticky sauce, comparable to okra. In Nigeria this sauce is found suitable for easy consumption of starchy balls made from cassava, yam or millet. A powder prepared from dried leaves is used to prepare this sauce during the dry season. The immature fruits, called bush okra, are also dried and ground to a powder for the preparation of this slimy sauce. In East Africa several recipes exist, e.g. Jew's mallow may be cooked with cowpeas, pumpkin, cocoyam leaves, sweet potato, milk and butter, meat, and flavoured with peppers and lemon.

Jute has been the most widely used packaging fibre for more than 100 years because of its strength and durability, low production costs, ease of manufacturing and availability in large and uniform quantities. However, jute production is insignificant in Africa. The types of *Corchorus olitorius* that are used as a leaf vegetable are quite distinct from the types used for jute production. Whole jute stems are suitable as raw material for paper pulp. However, when jute is used for pulping, it is usually in the form of cuttings from burlap manufacture, old sugar bags and wrappings. The resulting pulp is made into hard, thick paper, suitable for cards and labels. The woody central core ('stick') remaining after removal of the bast can also be processed into paper, board and cellulose.

Root scrapings of Jew's mallow are used in Kenya to treat toothache, a root decoction as a tonic, leafy twigs in Congo against heart troubles, an infusion from the leaves is taken in Tanzania against constipation, and seeds in Nigeria as a purgative and febrifuge.

Production and international trade Jew's mallow is one of the leading leafy vegetables in many countries and much cultivated and traded. No statistical data on production or marketing are available. International trade with neighbouring countries occurs, but is not registered. In Europe, Jew's mallow is sold in powder form as a Libanese product, under its Arab name 'meloukhia'.

The world jute production (combined data from *Corchorus olitorius* and *Corchorus capsularis*) has been stable over the past 40 years. In the period 2004–2008 it averaged 2.74 million t raw fibre per year. India (1.78 million t per year from 781,000 ha) and Bangladesh (827,000 t per year from 414,000 ha) together produced more than 95% of the total. The flood plains in the lower delta of the Ganges and Brahmaputra rivers combine optimum conditions for jute cultivation (with respect to climate, soil, and adequate surface water for retting) with the availability of inexpensive farm labour. Other countries with noticeable jute production in 2004–2008 were China (49,000 t/year), Uzbekistan (20,000 t), Nepal (17,000 t), Vietnam (14,000 t) and Myanmar (14,000 t). In tropical Africa jute was produced in Sudan (3900 t/year), Zimbabwe (2400 t) and Cameroon (100 t). Most jute fibre is processed within the producing countries. In 2004–2008 world raw jute fibre exports amounted to about 450,000 t per year, mostly from Bangladesh (400,000 t).

Properties The composition of *Corchorus olitorius* leaves per 100 g fresh edible portion is: water 80.4 g (74.2–91.1), energy 243 kJ (58 kcal), protein 4.5 g, fat 0.3 g, carbohydrate 12.4 g, fibre 2.0 g, Ca 360 mg, P 122 mg, Fe 7.2 mg, β-carotene 6410 µg, thiamin 0.15 mg, riboflavin 0.53 mg, niacin 1.2 mg, ascorbic acid 80 mg (Leung, Busson & Jardin, 1968). This composition is in line with other dark green leaf vegetables, but the dry matter content of fresh Jew's mallow leaves is higher than average. The composition and especially the micronutrient content are strongly influenced by external factors such as soil fertility and fertilization. Nitrogen fertilizer greatly improves the micronutrient content, e.g. Fe, P, Ca, carotene and vitamin C.

The mucilaginous polysaccharide in the leaves is rich in uronic acid (65%) and consists of rhamnose, galactose, glucose, galacturonic acid and glucuronic acid in a molar ratio of 1.0:0.2:0.2:0.9:1.7 in addition to 3.7% acetyl groups.

Jute fibres are obtained from the bast. The use is limited to coarse fabrics, because the length:diameter ratio of jute filaments is only 100–120, much below the minimum of 1000 required for fine spinning quality. Individual fibre cells are (0.5–)2–2.5(–6.5) mm long, with a diameter of (9–)15–20(–33) µm. The length of the fibre cells decreases from the top to the bottom of the stem, whereas the width increases. The lumen width varies greatly throughout the length of the fibre cell, with the lumen sometimes closing up. Fibre cells are cemented together into filaments of up to 250 mm long. The tensile strength, elongation at break, and Young's modulus of jute fibre are 187–775 N/mm^2, 1.4–3.1% and 3000–55,000 N/mm^2, respectively.

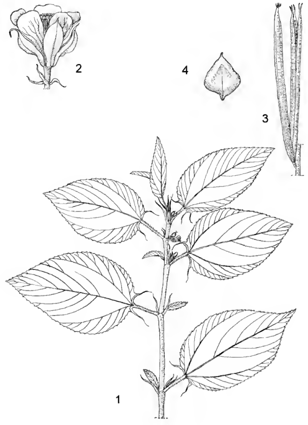
Jute has a low ignition temperature of 193°C, posing a considerable fire hazard in warehouses. Jute fibre contains 45–84% α-cellulose, 12–26% hemicelluloses, 5–26% lignin, 0.2% pectin and 1–8% ash. Jute fibre may be treated with a strong alkali ('woollenization'), resulting in a reduced fibre length, a softer feel and a crimp or waviness, giving the fibre a wool-like appearance. The woody central core is of medium durability under exposed conditions. The fibres in the central core are 0.5–0.8 mm long and 29–42 µm wide.

Corchorus olitorius leaves contain antioxidative phenolic compounds, of which 5-caffeoylquinic acid is the most important. Some ionone glucosides have also been isolated from the leaves; they showed inhibitory activity on histamine release from rat peritoneal exudate cells induced by antigen-antibody reaction. The seeds are poisonous to mammals and insects. They contain cardiac glycosides.

Adulterations and substitutes As ingredient of slimy sauces *Corchorus olitorius* can be replaced by other *Corchorus* species (also called Jew's mallow): the wild and cultivated *Corchorus tridens* L. and the wild species *Corchorus*

asplenifolius Burch., *Corchorus fascicularis* Lam., *Corchorus trilocularis* L. and *Corchorus aestuans* L.
The fibres of kenaf (*Hibiscus cannabinus* L.) and roselle (*Hibiscus sabdariffa* L.) are coarser and cheaper than jute. They are acceptable substitutes for jute in the manufacture of coarse packaging fabrics, Other bast fibres which can serve as substitutes for jute include those from Congo jute (*Urena lobata* L.) and devil's cotton (*Abroma augusta* (L.) L.f.). Since the second half of the 20th Century jute has faced substitution as sack-making material by synthetic fibres such as polypropylene and polyethylene.

Description Erect annual herb up to 2(–4) m tall, usually strongly branched; stems reddish, fibrous and tough. Leaves alternate, simple; stipules narrowly triangular with long point; petiole (0.5–)1–7 cm long; blade narrowly ovate, ovate or elliptical, 4–15(–20) cm × 2–5(–11) cm, cuneate or obtuse and with setaceous appendages up to 2.5 cm long at base, acuminate to acute at apex, margin serrate or crenate, almost glabrous, usually shiny dark green, 3–7-veined from the base. Inflorescence a 1–4-flowered axillary fascicle, bracteate. Flowers bisexual, regular, usually 5-merous, shortly stalked; sepals free, narrowly obovate, 5–7 mm long; petals free, obovate, 5–7 mm long, yellow, caducous; stamens numerous; ovary superior, usually 5-celled, style short. Fruit a cylindrical capsule up to 7(–10) cm long, ribbed, with a short beak, usually dehiscing by 5 valves, many-seeded. Seeds angular, 1–3 mm long, dark grey. Seedling with epigeal germination; hypocotyl 1–2 cm long; cotyledons foliaceous, broadly elliptical to circular, 3–8 mm long.



Corchorus olitorius – 1, flowering branch; 2, flower; 3, fruits; 4, seed.
Redrawn and adapted by Iskak Syamsudin

Other botanical information The genus *Corchorus* comprises an uncertain number of species, with estimates ranging from 40–100. Two important cultivar-groups of *Corchorus olitorius* exist. The vegetable types are combined in Olitorius Group, characterized by a plant height lower than 2 m, often not more than 1 m, and a more or less heavily branched plant habit. The fibre types are classified in Textilis Group, with plant heights of 4(–5) m and plants only slightly branched at the top. Within Olitorius Group, there are numerous local cultivars, e.g. early and late flowering, and with differences in plant habit and leaf shape. In Nigeria, the popular 'Amugbadu' is reputed to be suitable for transplanting and harvest by repeated cuttings; it has finely serrate, elliptical-ovate leaves, whereas 'Oniyaya' has smaller and coarsely serrate leaves, is strongly branched and more suitable for direct sowing and once-over harvest. 'Géant de Bertoua' from Cameroon has very large, broadly ovate leaf blades. Cultivars with deeply and irregularly serrate leaves ('Incisifolius') can be found in Benin and Cameroon.
Corchorus capsularis ('white jute'), an erect annual herb up to 2(–4) m tall with globose fruits, probably originates in southern China and was brought from there to India and Bangladesh where, till today, its production is centred. In the late 18th and early 19th century the crop was brought to many other tropical countries, but only in Brazil has the introduction been successful. Trials have been done in Gambia, Sierra Leone, Ghana, Nigeria, Sudan, Kenya, Uganda, Tanzania and Malawi. The failure of the crop in other countries than Brazil has been attributed to a wrong choice of cultivars and labour constraints. A new attempt to introduce *Corchorus capsularis* as a crop into tropical Africa would require considerable investment in facilities for post-harvest handling (e.g. ribboning, retting, washing), as without these, the production is unlikely to be economical. The fibre of *Corchorus capsularis*

is less fine, soft and lustrous than that of *Corchorus olitorius*. The former is usually whitish, whereas the latter is yellowish to reddish.

Growth and development Growth of *Corchorus olitorius* seedlings is fast. In short day conditions flowering starts about a month after emergence and continues for 1–2 months, depending on type and conditions. The flowers are usually self-pollinated, but cross-pollination up to 10% occurs. After about 3–4 months, the fruits are ripe, the leaves drop and the plant dies.

Ecology Wild plants of *Corchorus olitorius* grow in grassland and fallow or abandoned fields, often close to marshes, rivers and lakes, at up to 1250(–1750) m altitude. Jew's mallow thrives best under hot and humid conditions. In the savanna and Sahel zone, it performs best during the hot rainy season. It is cultivated where annual rainfall averages 600–2000 mm. The optimal temperature is 25–32°C. Growth stops below 15°C. Jew's mallow is a short-day species. In Nigeria a daylength of 12.5 hours caused a much stronger vegetative growth expressed in weight of roots, stems and leaves than a day length of 11.5 hours, but the fruit and seed production was higher at a photoperiod of 11.5 hours. Jew's mallow prefers sandy loam soils rich in organic matter and grows poorly on heavy clay.

Propagation and planting In general farmers have no access to improved seed, but harvest their own. They keep a few plants for that purpose in their garden or field until fruit maturity. For a good seed yield of 25 g per plant, a spacing of 50 cm between and within the row is recommended. Commercial seed production may be 600 kg/ha. The seed is ripe when all the leaves have dropped. For own on-farm seed production, the stems with fruits are harvested, and after drying in the sun they are kept until the next season. In villages in the north of Côte d'Ivoire, the women conserve the fruits in the kitchen above the fireplace. Fruits on abandoned plants in the field also still contain viable seed until the next rainy season. These fruits open at the onset of the rains and the seeds spread. Well-dried seed keeps a high germination capacity for several years. One g contains about 470 seeds. Fresh and sometimes old seed shows dormancy caused by impermeability of the seed coat. This is a major problem for Jew's mallow cultivation. To suppress the dormancy, it is recommended that the seed tied in a piece of cotton cloth be immersed for 5 seconds in almost-boiling water before sowing. Another method is scarification with sandpaper.

In traditional field cultivation, the farmers broadcast seed without any consideration concerning the optimal density. They often grow Jew's mallow in association with other vegetables or food crops such as okra, tomato, watermelon, groundnut or yam.

Peri-urban vegetable farmers produce Jew's mallow on beds in monoculture. Direct sowing is mainly applied for once-over harvest by uprooting or low cutting at soil level. Sowing is done in lines 30–50 cm apart and with spacing 10–15 cm in the rows. For the more common harvesting by repeated cuttings, 10–20 g seed per 10 m^2 is sown in a nursery in well-loosened soil. When the seedlings are 5–10 cm tall, they are transplanted at a spacing of 10–20 cm in the row and 30–50 cm between the rows. In trials in Ghana the highest yield, 50 kg of marketable shoots or 29 kg of edible leaves per 10 m^2, was obtained with a spacing of 10 cm × 45 cm.

Management Jew's mallow is usually grown as a rainfed crop without much care. In peri-urban production the growers practise manual irrigation during the dry season, at least 6 mm daily. Organic fertilizer may be applied at up to 20 t/ha. A basal application with NPK (e.g. 15–15–15 at 400 kg/ha) and a side dressing with nitrogen are recommended for an optimal yield. Nitrate fertilizer gives better results than ammonium-based ones.

Diseases and pests Jew's mallow is rather resistant to diseases and pests. *Sclerotium rolfsii* causing foot rot and wilting is sometimes a problem. *Curvularia* species cause black leaf spots, and *Cercospora* circular leaf spots. These fungal diseases are kept under control by cultivation on well-drained beds and wide spacing. A virus disease transmitted by leaf hoppers and causing leaf deformation and retarded growth was reported from Nigeria.

The most damaging pests are grasshoppers (*Zonocerus variegatus*), caterpillars (*Acrea* spp.), army worm (*Spodoptera littoralis*) and flea beetles (*Podagrica* spp.). During the dry season, red spider mites (*Tetranychus cinnabarinus*) often attack the leaves. Control by spraying with recommended pesticides is rarely applied.

Jew's mallow is very susceptible to root-knot nematodes (*Meloidogyne* spp.). Methods of control include crop rotation, avoiding other crops susceptible to root-knot nematodes for at least one year, and taking care to ensure a high organic matter content of the soil.

Harvesting The first harvest by cutting shoots 20–30 cm long may take place 4–6 weeks after transplanting at a height of 10–20 cm above the ground. This cutting stimulates the development of side shoots. Subsequently every 2–3 weeks a cutting may take place, in total 2–8 cuttings. For a once-over harvest from a direct sown crop the plants are uprooted or cut at ground level when they are 30–40 cm tall, 3–5 weeks after emergence and before development of fruits. The plants are bundled for marketing. In intercropping systems farmers tend to harvest at irregular intervals. Wild Jew's mallow is picked from the vegetation when required, usually for home consumption.

A crop planted for jute production is generally harvested 100–120 days after sowing when the plants are in the early fruit stage.

Yield In Nigeria a yield of 20–25 kg per 10 m^2 bed may be expected from 3–9 cuttings of 'Amugbadu' during a period of 3–4 months. In an experiment in Cameroon a yield of 38 t/ha was obtained from a well-fertilized field of cultivar 'Ewondo'. Farmers however, usually obtain average yields of 5–15 t/ha.

The world average jute yield is about 2.2 t of raw fibre per ha, but yields of 5 t/ha have been obtained in Bangladesh with improved cultivars grown under optimal agronomic conditions.

Handling after harvest Jew's mallow leaves cannot be kept long. Mostly the product is sold on the harvest day, and it is constantly kept wet. If cooled to 20°C it can be kept for about 1 week, in cold storage for several weeks. If the leaves are dried and pounded to powder, the product can be kept for at least half a year.

Jute stems are retted in water for a period of (8–)15–20(–30) days to free the fibres from the bark. When retting is complete, the fibres are stripped manually from the stems, subsequently washed and dried, and then graded and packed.

Pulping of waste material such as burlap pieces and old bags is primarily done with chemical processes such as the soda process. Retted fibre can be satisfactorily pulped with the refiner mechanical pulping (RMP) process; treatment with the white rot fungus *Ceriporiopsis subvermispora* prior to refining results in considerable energy savings and increased strength properties. Unretted bast fibre has been experimentally pulped using the neutral sulphite-anthraquinone (NS-AQ) process, but yields were low and the input of chemicals high, compared to the pulping of retted fibre. The central cores can be pulped with various chemical and chemi-mechanical processes. Pulping experiments with whole stems showed that the soda-amine process (soda process with amines as additives) gave higher yields and better physical properties than the soda and kraft processes.

Genetic resources The risk of genetic erosion is negligible because there is almost no commerce of seed of improved cultivars. At the Nigerian Horticultural Research Institute NIHORT at Ibadan, a collection of local types is maintained. The genebank of the Bangladesh Jute Research Institute in Dhaka has the mandate of world repository for germplasm of jute. It has a collection of almost 1500 *Corchorus olitorius* accessions through various germplasm collection projects in Asia and East Africa.

Breeding Farmers select the most vigorous plants with the best mucilaginous properties. When smaller leaves are required, farmers select for profuse branching. At NIHORT in Ibadan selections have been made for rapid early growth, large leaf size, dark green glossy leaves and late flowering. Hand crossing appeared difficult because of flower drop after emasculation.

Jute selection with the objectives of higher yield, finer fibre quality, disease resistance, early crop maturity and low photosensitivity has been practised for many years in Bangladesh and India and has resulted in several successful *Corchorus olitorius* cultivars.

Prospects Jew's mallow is a high quality leafy vegetable in market value, consumers' preference and nutritional value. Reliable seed of improved cultivars should become commercially available. It is recommended that local cultivars be collected and tested for useful characteristics including adaptation to various environments, resistance to diseases and yield. It seems impossible for Africa to compete in export markets for jute, in view of the excellent conditions for jute cultivation in Bangladesh and India.

Major references Burkill, 2000; Denton, 1997; Edmonds, 1990; FAO, 2011; Franck (Editor), 2005; Khandakar & van der Vossen, 2003; Leung, Busson & Jardin, 1968; Schippers, 2000; Stevels, 1990; van Epenhuijsen, 1974.

Other references Akoroda, 1988; Biagiotti, Puglia & Kenny, 2004; Grubben, 1977; M'bah-Ngami, 1998; Mwaikambo, 2006; Norman, 1992; Ohtani et al., 1995; Peeler, 1967;

Purseglove, 1968; Singh, 1976; van der Zon & Grubben, 1976; Westphal et al., 1985.

Sources of illustration Bosser, 1987.

Authors L. Fondio & G.J.H. Grubben

CROTALARIA JUNCEA L.

Protologue Sp. pl. 2: 714 (1753).

Family Papilionaceae (Leguminosae - Papilionoideae, Fabaceae)

Chromosome number $2n = 16$

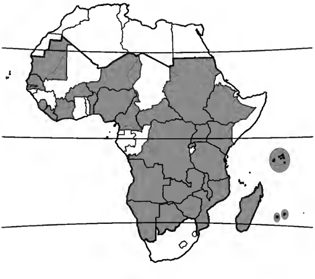
Vernacular names Sunn hemp, Indian hemp, Madras hemp, sann hemp, sun hemp, Bombay hemp, brown hemp (En). Chanvre indien, chanvre du Bengale, crotalaire jonciforme, cascavelle (Fr). Cânhamo-da-India, cânhamo-de-bengala (Po).

Origin and geographic distribution *Crotalaria juncea* is generally considered to be native to Bangladesh, Bhutan and India. It is now widely cultivated in the drier areas of the tropics and subtropics and in many temperate areas with a hot summer. It often escapes from cultivation, naturalizes easily and grows in many areas as a ruderal plant. *Crotalaria juncea* is recorded in many countries across the African continent from the Atlantic coast to the Red Sea, from Tunisia to South Africa and in the Indian Ocean islands.

Uses The strong bast fibre is used primarily for cordage, twine, fishing nets, cigarette paper, tissue paper, bags, sacks, canvas, soles of shoes and sandals. Other products include carpets, webbing, table and bed linen. With the fibres a potting medium is manufactured.

Crotalaria juncea is one of the most widely grown green manure crops of the tropics, often in rotation or as an intercrop with rice, maize, sorghum, tobacco, cotton, sugarcane, pineapple, coffee and in orchards. It is also grown to suppress weeds, to prevent soil erosion and to reduce nematode numbers. *Crotalaria juncea* is a good indicator plant for potassium and calcium deficiencies.

The dried stalks and hay are used as forage. Although reported to be poisonous to livestock, seeds are fed to horses in the Soviet Union and to pigs in Zimbabwe. The woody stems remaining after fibre removal are used as fuel. Seeds are used in the production of an adhesive for plywood and as a coffee-substitute. The seeds are used medicinally to purify the blood, to cure impetigo and psoriasis and as an emmenagogue.



Crotalaria juncea – planted and naturalized

Production and international trade *Crotalaria juncea* has been grown as a fibre crop in India since 600 BC and is one of the earliest recorded fibre crops in history. The fibre was first introduced into Europe in 1791 by the East India Company, during a period when jute (*Corchorus* spp.) was considered a fibre plant of less importance. The fibre of *Crotalaria juncea* proved to be excellent and not inferior to hemp (*Cannabis sativa* L.). Major producers of *Crotalaria juncea* include India, Bangladesh, China, Brazil, Korea (DPR), Pakistan, Romania and Russia. Currently China is the main producer of *Crotalaria juncea* in the world. The fibre is exported mainly to the United States, the United Kingdom, France, Italy, Belgium, Argentina, Greece and Russia. However, the export market has gone down badly due to increased availability of hemp from Italy and Russia in the world market. India grows about 360,000 ha of *Crotalaria juncea* annually, producing between 80,000 and 100,000 t of fibre, with about 20–30% being exported to the United Kingdom, the United States and Belgium. The imports into the United States and the United Kingdom are mainly used in the manufacture of cigarette and high quality tissue papers.

There are no statistical data on traded volumes in Africa. In Kenya and Uganda the cultivated area is approximately 3000–5000 ha, mainly as a homegarden crop. All trade in tropical Africa is through local or regional markets and international trade is limited to local cross-border trade.

Properties The major significance of *Crotalaria juncea* lies in its valuable bast fibre, which makes up about 8% of the dry stem weight. The fibre of commerce consists of greyish to pale yellow strands 75–150 cm long. Fibres are entangled in a mesh structure, and single filaments are obtained by combing and splitting the mesh structure. The ultimate fibre cells are (0.5–)6–8(–20) mm long and (10–)25–30(–50) µm wide, with a cell wall thickness of 3–11 µm. The cells often have rounded ends, but these may also be blunt or pointed. They are rounded polygonal or oval in cross-section, with thick walls. Dislocations, cross-markings and longitudinal striations are present. The fibre has a tensile strength of c. 73 kg/mm^2 and an elongation at break of 5.5%. It is stronger and more durable under exposure than jute (*Corchorus* spp.), but it is not as strong as hemp (*Cannabis sativa* L.). The fibre is stronger when wet than when dry, and is fairly resistant to mildew, moisture and microorganisms in salt water, making it particularly suitable for fishing nets and marine cordage. The fibre contains 10% moisture, 67.8% cellulose, 16.6% hemi-celluloses, 3.5% lignin, 0.3% pectin, 1.4% water solubles and 0.4% fat and wax.

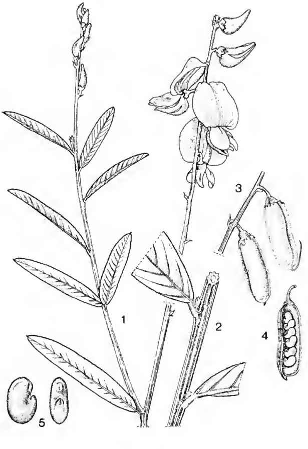
The fibre possesses properties that make it an excellent choice for papermaking: good yields of bleachable sulfate pulps; pulp strength properties that are equal to or greater than those of most mixed hardwood pulps; and a fibre length to width ratio that is greater than those of wood fibres. The high cellulose content as well as degree of polymerisation makes this fibre ideal for preparing specialty paper. Prepared pulps are suitable for a wide range of end uses. The fibres are particularly suitable for cigarette paper because of the high cellulose and low ash content.

The stems have the following major constituents: cellulose 78.3%; pentosan 3.6%; urinic anhydrite 1.7%; acetyl content 1.5% and lignin 4.0%. Minor constituents include: fat and wax 0.5%; nitrogenous matter 1.4% and ash 0.3%. Monosaccharide constituents include the following: glucose 80.3%; xylose 5.2%; mannose 11.7%; galactose 2.1%; arabinose 1.7% and rhamnose 0.4%. Dried for cattle feed, the stalks contain 14.4% moisture, 1.1% ether extract, 11.3% albuminoids, 35.8% carbohydrate, 27.4% woody fibre, and 6.4% soluble mineral matter. The hay is mildly toxic, mainly to horses, but cattle can eat it safely when it does not form more than 10% of the total feed intake.

Seeds contain 8.6% moisture, 34.6% crude protein, 4.3% fat, 41.1% starch, 8.1% fibre, and 3.3% ash. Seeds are reported to contain trypsin inhibitors, and are said to be poisonous to cattle. Seeds oil contains 46.8% linoleic acid, 4.6% linolenic acid, and 28.3% oleic acid, and, by difference, 20.3% saturated acids. The seeds contain the toxic pyrrolizidine alkaloids trichodesmine, juncein, senecionine and seneciphylline and 25.6% of the polysaccharide galactomannan.

Adulterations and substitutes Fibre plants used for the same purpose as *Crotalaria juncea* include cantala (*Agave cantala* Roxb.), sisal (*Agave sisalana* Perrine), hemp (*Cannabis sativa*) and jute (*Corchorus* spp.)

Description Erect laxly branched annual herb up to 1.5(–3.5) m tall; stems ribbed with short appressed hairs. Leaves alternate, simple; stipules 1–2 mm long, slender; petiole 3–5 cm long; leaflets oblong-lanceolate, 5–13(–18) cm × 0.5–3 cm, finely appressed pubescent. Inflorescence a leaf-opposed raceme 10–50 cm long, laxly 6–20-flowered; bracts elliptical, 3–5 mm long. Flowers bisexual, zygomorphic, 5-merous; calyx 1.5–2 cm long, covered in short brown hairs with some longer ones interspersed, lobes 3–4 times as long as the tube; corolla bright yellow, with elliptical standard faintly reddish marked or tinged, wings a little shorter than keel, keel 17–22 mm long, with a



Crotalaria juncea – 1, flowering branch; 2, part of stem; 3, fruits; 4, opened fruit; 5, seeds.
Source: PROSEA

long, slightly incurved twisted beak; stamens 10, all joined in a sheath open at base; ovary superior, 1-celled, style curved, stigma small. Fruit a cylindrical pod 30–55 mm × 12–17 mm, short, velvety hairy, 6–12-seeded. Seeds oblique-cordiform, 6–7 mm long, dark brown to black.

Other botanical information *Crotalaria* comprises about 600 species and occurs throughout the tropics. Africa is by far richest with approximately 500 species. *Crotalaria juncea* is the economically most important species of the genus. *Crotalaria spectabilis* Roth. ('showy rattlepod', 'showy crotalaria') is another species with simple leaves imported from Asia into West Africa and Madagascar for use as a fibre plant, green manure, and for fodder. In Asia it is planted as an ornamental and for erosion control as well. Further introductions of this species are discouraged as the species is very poisonous due to the presence of the pyrrolizidine alkaloid monocrotaline, and apparently has no advantages over *Crotalaria juncea*. Also of Indian origin is *Crotalaria berteroana* DC. (synonym: *Crotalaria fulva* Roxb.), introduced in Madagascar as a fibre crop and green manure and now widely naturalized. In Madagascar the pulverized grains are used as a plaster to cure scabies. The large amount of scientific papers on the species was triggered by the use in Jamaica in bush tea. This use appeared to be the cause of vascular lesions of the liver described as 'veno-occlusive disease' in Jamaica and attributed to the presence of the hepatotoxic pyrrolizidine alkoloid fulvine in the leaves and seeds. *Crotalaria xanthoclada* Bojer ex Benth. is an endemic of Madagascar; it produces a textile fibre and its seeds are toxic to poultry.

Growth and development The seeds of *Crotalaria juncea* normally germinate within about 3 days. Too much moisture is harmful during the first 2 weeks after sowing. *Crotalaria juncea* is a short-day plant, and long days favour vegetative growth and reduced seed-set. Daylength neutral selections exist. The time from germination to flowering can be as short as 30 days. The lowest flowers of the inflorescence are the first to open and flowers remain open for 2 days. Extensive cross-pollination occurs and self-pollination only takes place after the stigmatic surface is stimulated by an insect or mechanically. Seed set is practically nil when the flowers are kept inside muslin bags. The plant fixes atmospheric nitrogen in a symbiotic relationship with *Rhizobium*. Nitrogen content of the vegetative parts is highest from the onset of floral initiation to mid bloom, after which it declines as N reserves are allocated to seed production.

Ecology *Crotalaria juncea* is drought resistant and is adapted to hot, semi-arid and arid areas. It tolerates light frost. In India it is grown in areas with 170–200 mm of rain during the growing period, but elsewhere it is often grown in areas with higher rainfall. It is not tolerant to salt or to prolonged waterlogging. It is adapted to a wide range of soil types. It grows on poor soils but growth on these soils is improved by fertilization. A near neutral pH range of 6–7 with an improved phosphate availability is often beneficial to the crop.

Propagation and planting *Crotalaria juncea* is propagated by seed. The 1000-seed weight is 30–55 g. Several pre-emergence herbicides (e.g. clomazone at 1.4 kg/ha) have been identified as causing minimal phytotoxicity and providing efficient weed control. The soil moisture should not be below 30% to allow for good germination. Sowing in rows is recommended with a distance between rows of 25–30 cm. Distance within the row should be 5–7 cm and sowing depth 2–3 cm. For fibre production *Crotalaria juncea* seed is often broadcasted at a rate of c. 100 kg/ha under rainfed conditions and at a lower rate if irrigated. In Pakistan seed is sown broadcast at a rate of 120–240 kg/ha but when planted in rows 30 cm apart, a seed rate of 66 kg/ha can lead to fibre yields 10% higher than when using the higher broadcasting rate. A high seed rate ensures upright erect stems which help to smother weeds, produce a finer fibre and increase the yield. Planting dates differ by location. Adequate soil moisture and frost-free, warm weather conditions will ensure rapid emergence and a high yield.

Management The land should be well prepared before sowing. It is recommended to apply organic manure at a rate of 3–5 t/ha before land preparation. As a green manure *Crotalaria juncea* is mainly grown during the rainy season. For fibre, it is grown on fairly light, well-drained, sandy loam or loamy soils that retain sufficient moisture during the growing season. Vigorous growth can also be achieved on clay or low lying soils but the fibres will be coarser and yields lower. Although reports on fertilization requirements vary, additions of phosphorus are generally recommended. The fibre quality is improved by increasing N, P and K levels, the effect being strongest for K. No herbicides other than for pre-emergence use are currently registered for *Crotalaria juncea*.

It is fast growing and generally suppresses weeds by shading but early season weed control has been shown to improve yields when grown for fibre. Where irrigated, furrows are opened in fields dividing them into small plots. If there is no rain after sowing, the field is irrigated along these furrows at intervals of 10–15 days.

As a green manure it is ploughed in as of 2 months after sowing when the plants begin to flower as it decomposes more rapidly and it will have a positive N balance at this stage. Elsewhere it was concluded that green manure fallow duration should be at least 6 months for it to have a positive effect on soil characteristics. A fallow of up to 18 months was found to be beneficial for soil fertility but the economic consequences of such a long fallow should be taken into consideration.

Diseases and pests Although many diseases and pests have been recorded for *Crotalaria juncea* from India and the United States, no serious problems are recorded for the species in tropical Africa. If it is to be grown at a larger scale in future, disease and pest problems will undoubtedly arise. It is vulnerable to many diseases and pests that also affect crops like cowpea, soybean, groundnut and pigeon pea. *Bemisia tabaci* (whitefly) is an important vector for the transfer of virus diseases. *Crotalaria juncea* is resistant to the nematodes *Meloidogyne javanica* and *Pratylenchus* sp. and is succesfully used in rotation to reduce the infestation of the soil by these nematodes. It may however increase the population of the free-living nematodes *Xiphimena elongatum* and *Helicotylenchus* sp. It is immune to the parasitic weed *Alectra vogelii* Benth. and therefore useful in the rotation wherever this weed is a problem.

Harvesting Most cultivars are ready for harvesting 120–150 days after sowing. Harvesting of the crop at the proper time is very important for ensuring optimal yield as well as optimal fibre quality. Often it is better to harvest the crop at 50% flowering or early pod-stage to compromise between yield and quality. In Zimbabwe the crop is cut when stems have turned yellow along the major portion of their length. If grown for seed, plants are harvested after seeds are well set, and before pods are dry, so that no seed is lost during cutting and bundling prior to threshing. Harvesting at flowering stage gives a finer fibre, but profit obtained from the seed crop is thereby lost.

Harvesting is done manually with the help of sickles and knives at ground level. The stems are sorted for length and thickness and stems of equal sizes are tied in bundles of 20–25 cm diameter and these are kept in the field for 2–3 days for shedding of leaves. The cut stems are graded by pulling out the long and medium stems respectively. Direct chopping with forage harvesters has been successful, but a precise cut is difficult to obtain and the chopped material has proved too bulky to handle. In Europe and the United States *Crotalaria juncea* is already harvested mechanically by cutting, drying in swathes on the field for a few weeks and subsequently pressing and baling in a single operation.

Yield Dry matter yields vary enormously, depending on factors such as fertilizer application and intensity of weeding, and may be as high as 14 t/ha. Average fibre yields are 560–900 kg/ha, while in Zimbabwe the average yield is about 330 kg fibre per ha. Seed yields are 500–1000(–2500) kg/ha.

Handling after harvest After the cut stems have dried sufficiently and have shed their leaves, the bundles are retted. The number of days required for retting depends on factors such as temperature, locality, thickness of stems and quantity of stems in relation to the volume of water. In Zimbabwe 10–14 days are required for retting in July, 8–9 days in August and 5–8 in September–October. Cement tanks are preferred for retting, but earth pits, dams, weirs, streams, and backwater pools of rivers are also used. Shallow water 1–1.3 m deep is satisfactory. If more than one ret is to be carried out in a pool, a sufficient flow of water must be maintained to prevent fouling of the water and discolouration of the fibre. Four or five men are required to remove and stack one tonne of straw per day. Bundles are stood on end (15–20 stems placed with butts on ground at a sufficient angle to permit air circulation in all directions). In this way the straw dries in 1–2 weeks. By standing each bundle up and fanning out the butts, drying time is reduced to 4 days. By leaning bundles on each side of a rack, drying time is reduced to 3–4 days. After the fibre is stripped from the stalks by hand, it is washed and hung over bamboo poles to dry in the sun. Cut straw with a yellowish tinge requires 10–21 days to bleach sufficiently so as to have a fibre of a satisfactory colour. Stems cut while green will bleach when exposed directly to the sun but have to be turned at least twice. Precautions must be taken against under-retting or over-retting of fibre. In under-retted condition, removal of fibres will be a difficult task as bark will adhere to the extracted fibre. While in over-retted condition microorganisms will break down the tissues surrounding the fibre and this will result in weakening of the fibre. The fineness of the fibre and cleanness or degree of retting are decisive for processing to ropes and textiles. A better fibre quality can be obtained by cottonization involving the chemical or mechanical rearrangement of the bast fibre. This makes it possible to process the fibres of *Crotalaria juncea* on cotton spinning machines. By adopting flax spinning machinery, it is possible to produce coarse fabrics for hose pipes, belting and canvas.

If paper companies had suitable cutting devices, binders or hay balers could probably be modified to handle whole stalks. The end-product influences the type of cut that is necessary. For example, board and mechanical pulps require a shorter, more precise cut than a chemical pulp in which a separation of the ultimate fibre occurs.

Genetic resources *Crotalaria juncea* is distributed widely but is not known from the wild, and genetic diversity depends largely on being preserved in farmers' fields. Major germplasm collections are maintained by the Institute of Crop Germplasm Resources (CAAS), China, the Vavilov All-Russian Scientific Research Institute of Plant Industry (VSRI), Russia, the Plant Genetic Resources Conservation Unit (PGRCU) in the United States and the Sunnhemp Research Station in India.

Breeding Genetic variation is fairly large. In Europe breeding and selection work is aimed at obtaining high quality fibre. Numerous cultivars exist and include the following: 'Madaripur', 'Seraganj' (Pakistan); 'Somerset' (South Africa); KRC-1 (Brazil); 'Tropical sun' (Hawaii, United States); 'Kharif-sunn', 'Chindwara', 'Bellary, 'Jabalpur', 'Belgoan' (India).

Prospects Worldwide demand for natural fibre is increasing and current fibre supplies cannot continue to meet the market demands. *Crotalaria juncea* has the potential to be grown on a large commercial scale and can contribute to satisfy the increased demand for natural fibres. It is of economic importance in the tropics and subtropics and great steps have been made in the development of *Crotalaria juncea* as a fibre crop for the temperate regions. Demand depends on the price of the fibre in relation to that of alternatives and both supply and price have fluctuated considerably in the past. With research to develop new products the demand will increase even more in the future. Compared to other bast fibre plants *Crotalaria juncea* has the advantages of being able to fix atmospheric nitrogen and being resistant to drought and root-knot nematodes. It is adapted to a range of ecological conditions and can be used for soil rehabilitation and protection. Research should focus on product development, harvesting and processing equipment, and efficient crop management strategies.

Major references CAB International, 2010a; Chee & Chen, 1992; Cook & White, 1996; Dempsey, 1975; Gillett et al., 1971; Jarman, 1998; Kirby, 1963; Polhill, 1982; Stefanesco & Bintoni-Juliassi, 1982; White & Haun, 1965.

Other references Becker & Johnson, 1999; Bogdan, 1977; Boiteau, Boiteau & Allorge-Boiteau, 1999; Burkill, 1995; Catling & Grayson, 1982; Cunningham, Clark & Bagby, 1978; Decary, 1946; Duke, 1983a; Franck (Editor), 2005; Ganunga, Yerokun & Kumwenda, 2005; Kabambe et al., 2008; Kay, 1994; Kimenju et al., 2007; Maiti, 1979; Morris, 1997; Morris & Kays, 2005; Nezomba et al., 2008; Niyomdham, 1997; Rhodes, Antwerpen & Berry, 2009; Xiuhong et al., 2005.

Sources of illustration Chee & Chen, 1992.

Authors A. Maroyi

CRYPTOLEPIS OBLONGIFOLIA (Meisn.) Schltr.

Protologue J. Bot. 34: 315 (1896).

Family Asclepiadaceae (APG: Apocynaceae)

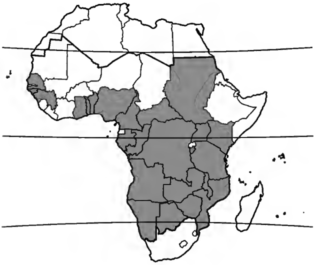
Synonyms *Ectadiopsis oblongifolia* (Meisn.) Schltr. (1893), *Cryptolepis nigritana* (Benth.) N.E.Br. (1902).

Vernacular names Red-stemmed cryptolepis (En).

Origin and geographic distribution *Cryptolepis oblongifolia* is widely distributed in tropical Africa and also native to South Africa and Swaziland.

Uses Fibre from the stem bark is used to make thread and fine rope in Sudan, Tanzania, Malawi, Zimbabwe and Mozambique. In Malawi fishing nets are made from the fibre, and in Zimbabwe fishing lines and headgear for horses. In Benin and Malawi the leaves are eaten cooked as a vegetable. The fruits are eaten in Tanzania.

In traditional medicine in Tanzania and Zimbabwe root preparations are used to cure coughing, stomach ache and diarrhoea in children, and a root decoction is taken as an aph-



Cryptolepis oblongifolia – wild

rodisiac. In Zambia the pulped root bark is applied as wound dressing and in Benin and Zambia the pulped or powdered root bark is taken for the treatment of gonorrhoea. In several countries the latex or a leaf decoction is dripped in the eye to cure sore eyes, conjunctivitis and cataract. In Mozambique the leaves are used as a cure for malaria.

Properties The leaves of *Cryptolepis oblongifolia* contain traces of flavonins and the leaves, bark and roots contain steroids and terpenes. From bark collected in Malawi the xanthones 1,7-dihydroxy-4-methoxyxanthone and 1,2,7-trimethoxyxanthone were isolated.

Botany Erect, branching shrub up to 2 m tall, with long, slender branches up to 60 cm long, reddish brown, containing white latex. Leaves opposite, simple and entire, glabrous; stipules absent; petiole very short; blade linear to lanceolate, rarely oblong or ovate, up to 10 cm long, base cuneate, apex acute, mucronulate. Inflorescence an axillary cyme up to 18 mm in diameter, with few to many flowers. Flowers bisexual, regular, 5-merous, yellowish green; pedicel 2–3 mm long; sepals oblong, obtuse; corolla campanulate, tube 1.5–2 mm long, lobes 3–4 mm long, contorted to the left in bud; corona lobes inserted at the middle of the corolla tube, fleshy, c. 0.5 mm long. Fruit a pair of spreading follicles, each straight, tapering to a blunt apex and up to 14 cm × 1 cm. Seeds oblong-elliptical, c. 1 cm long, crowned with a dense coma of long silky hairs.

In West Africa *Cryptolepis oblongifolia* flowers in May–July and fruits ripen around October.

Cryptolepis belongs to subfamily *Periplocoideae*. The genus comprises about 30 species in Africa, Asia and Australia. The majority of the species occur in East Africa and on Socotra (Yemen).

Ecology *Cryptolepis oblongifolia* occurs from sea-level up to 1800 m altitude in savanna woodland.

Genetic resources and breeding *Cryptolepis oblongifolia* is widespread and is not threatened with genetic erosion.

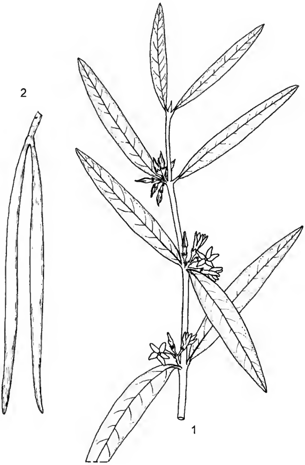
Prospects As a fibre plant *Cryptolepis oblongifolia* will not become more important than it is now but its medicinal uses warrant further research.

Major references Bullock, 1963; Burkill, 1997; Venter & Verhoeven, 1997; Williamson, 1955.

Other references Achigan-Dako et al. (Editors), 2009; Brown, 1902–1904; Bruce, 1946; Bullock, 1955; Fowler, 2006; Galeffi et al., 1990; Irvine, 1961; Matavele & Habib, 2000; Neuwinger, 2000; von Koenen, 2001.

Sources of illustration Akoègninou, van der Burg & van der Maesen, 2006.

Authors C.H. Bosch



Cryptolepis oblongifolia – 1, part of flowering stem; 2, fruits.
Source: Flore analytique du Bénin

CTENIUM ELEGANS Kunth

Protologue Révis. Gramin. 1: 295 (1830).

Family Poaceae (Gramineae)

Synonyms *Chloris elegans* (Kunth) Roberty (1955).

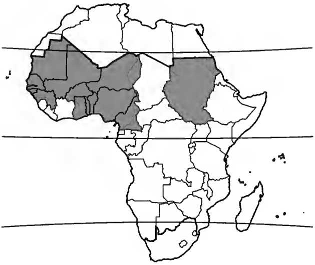
Origin and geographic distribution *Ctenium elegans* is distributed from Mauritania and Senegal eastward to Sudan. It possibly also occurs in Gabon.

Uses The stems are used as thatching material for huts. In Ghana the grass is woven into baskets plastered outside with cow dung to make beehives. Salka people in north-western Nigeria make it into conical covers for beehives. In Niger the stems are used for making mats and brooms. *Ctenium elegans* has been tested for producing paper pulp with positive results.

Records of stock grazing *Ctenium elegans* are ambiguous; in some places it is taken when young, elsewhere not. The foliage is aromatic and smells like citronella or lemon, which may account for cattle sometimes shunning it. Still, it is used for stall feeding in commercial dairy production.

Production and international trade *Ctenium elegans* is only used and traded locally.

Botany Annual, densely tufted grass; stems erect, up to 120 cm long, wiry, cylindrical, unbranched, glabrous, often broken. Leaves alternate, aromatic; sheath slightly hairy near the tip, otherwise glabrous; ligule very short, membranous; blade linear to ribbon-shaped, up to 30 cm × 3 mm, margin rough, lower part flat, upper part rolled-in, glabrous or with a few hairs axially near the base. Inflorescence a solitary, terminal spike up to 30 cm long, unilateral, tending to curl; rachis short-hairy. Spikelets laterally compressed, 3–6 mm long, sessile, solitary, comprising 2 basal sterile florets and 1 fertile floret; callus pubescent; glumes very unequal, margins hyaline, lower glume very small, awl-shaped, persistent, upper glume larger than the floret, 4–6 mm long, rigid, 2-veined, with an awn up to 2 mm long; basal sterile florets dissimilar, without significant palea, lemma of lower sterile floret oblong, hyaline, with awn 6–10 mm long, lemma of upper sterile floret oblong, slightly longer than that of lower sterile floret, hyaline, with awn 6–10 mm long; lemma of fertile floret ovate, 2–3 mm long, membranous, keeled, 3-veined, with 2–8 conspicuous apical hairs 2 mm long, with awn 6–10 mm long, palea of fertile floret 2-veined; lemmas of the lower florets and palea of the fertile floret with a line of yellow glands. Fruit an oblong-ellipsoid caryopsis 1–1.5 mm long.



Ctenium elegans – wild

Ctenium elegans flowers late in the rainy season. It is a C_4 plant. It should be noted that *Chloris elegans* Kunth is a synonym of *Chloris virgata* Sw. and not of *Ctenium elegans*.

Ctenium comprises about 8 species in Africa and 14 in the tropical Americas. It is characterized by the distribution of florets along the spikelets, with from the base 2 sterile florets, 1 perfect floret, and 1–4 male or barren florets. *Ctenium canescens* Benth. is a perennial, tufted grass with stems up to 120 cm long, occurring from Côte d'Ivoire to Nigeria in savanna on degraded sandy soils. The stems are used for thatching. *Ctenium newtonii* Hack. is a perennial, tufted, wiry grass with stems up to 1 m long, occurring from Senegal to Sudan, Uganda, Zambia and Angola. In northern Nigeria it is used for thatching. The leaves are aromatic, and it is not much grazed. Where over-grazing eliminated other, more palatable grasses, it has colonised large areas as locally in Sudan. In northern Nigeria its presence is taken as an indicator of overgrazing.

Ecology *Ctenium elegans* typically occurs in the Sahel zone, in open forest, savanna and grassland, often on poor, sandy and sometimes gravelly or lateritic soils, in dry or temporarily wet places.

Management Plants are sometimes conserved in cultivated fields. Propagation by seed is possible. Under favourable conditions, germination occurs after about 4 days.

Genetic resources and breeding *Ctenium elegans* is widespread and common. It is not in danger of genetic erosion.

Prospects *Ctenium elegans* will remain a grass of occasional use for thatching and basketry. Its potential as a fodder species is very limited.

Major references Burkill, 1994; Clayton, 1963; Poilecot, 1995; Poilecot, 1999; van der Zon, 1992.

Other references Anonymous, 1921; Ayantunde et al., 2009; Breman & de Ridder, 1991; Diogo, Buerkert & Schlecht, 2010; JIRCAS, 2005–2009; Le Houérou, 1980.

Authors L.P.A. Oyen

CULCASIA SERETII De Wild.

Protologue Pl. Bequaert. 1: 172 (1922).

Family Araceae

Chromosome number $2n = 42$ (hexaploid)

Synonyms *Culcasia bequaertii* De Wild. (1922), *Culcasia sapinii* De Wild. (1922).

Origin and geographic distribution *Culcasia seretii* occurs from Guinea, Sierra Leone and Liberia eastward through Côte d'Ivoire, Ghana, southern Nigeria and Cameroon to Equatorial Guinea, Gabon and DR Congo.

Uses Stems are used as tying material in construction.

Production and international trade *Culcasia seretii* is only used locally.

Botany Climbing, slender, diffuse herb up to 5 m tall; stems 2–4 mm in diameter, rough, brown, with conspicuous adventitious roots up to 2 cm long. Leaves alternate, simple and entire; petiole slender, 5.5–13 cm long including sheath of up to 7 cm, gradually narrowing; blade linear-elliptical to oblong-elliptical, 9–28 cm × 2–7 cm, base cuneate and decurrent, apex long-acuminate, deep glossy green, copper-coloured when young, lateral veins conspicuous, in 6–10 pairs merging into a conspicuous marginal vein or 2 basal pairs extending to apex, latex ducts few, with internal, translucent glands. Inflorescence a spadix, solitary or in groups of up to 4 per node, 2.5–4.5 cm long, cylindrical, slightly clavate at apex, exceeding the spathe at flowering, white or creamy, on c. 7 mm long stipe, male part 2–2.5 cm long, of which 0.5–1 cm with pink sterile flowers, female part shorter, 5–8 mm wide, no free space between male and female part; spathe up to 4 cm × 1.5 cm, basal 2.5 cm convolute, gaping apically at flowering, deep bronze-green outside, slightly paler with darker stripes inside; peduncle slender, 6–20 cm × c. 2.5 mm, greenish bronze. Flowers unisexual and naked; male flowers reduced to 2–4 stamens, stamens 1–2 mm long; female flowers reduced to a depressed globose ovary, 2–3 mm high, with stigma sessile, discoid, 1–1.5 mm in diameter. Fruit a spherical to ellipsoid berry 10–22 mm × 6–15 mm, dull orange or red. Seed ellipsoid, c. 8 mm × c. 4 mm, greenish brown, testa thin, smooth.

Culcasia comprises about 27 species and is restricted to tropical Africa, from Senegal to Ethiopia, Tanzania and Angola.

Ecology *Culcasia seretii* occurs at 150–800 m altitude in shady places in dense humid forest, in the undergrowth of secondary forest or along water courses.

Management *Culcasia seretii* is only collected from the wild.

Genetic resources and breeding *Culcasia seretii* has a wide area of distribution and does not seem in danger of genetic erosion, except where its habitat is disturbed.

Prospects *Culcasia seretii* is likely to remain of incidental use.

Major references Boyce, 1995; Hepper, 1967; Knecht, 1983; Ntépé-Nyame, 1988; Tra Bi, 1997.

Other references Hepper, 1968b; Tra Bi, Kouamé & Traoré, 2005.

Authors L.P.A. Oyen

CURCULIGO SEYCHELLENSIS Bojer ex Baker

Protologue Hort. Maurit.: 342 (1837).

Family Hypoxidaceae

Vernacular names Coco marron, koko marron (Fr).

Origin and geographic distribution *Curculigo seychellensis* is endemic to the Seychelles.

Uses Fibre from the leaf is locally used for making cordage. The leaf or string made from the leaf is used for wrapping or binding plugs of tobacco leaves.

Botany Herb with basal leaves up to 2.5 m long and a perennial tuber. Leaves bifid; petiole 30–45 cm long, armed with spreading prickles; blade broadly lanceolate, 30–200 cm long, base cuneate, apex split, leathery, strongly ribbed. Inflorescence a dense head, nearly sessile, with 50 or more flowers; bracts 5–7.5 cm long, lanceolate, densely hairy. Flowers bisexual, regular, 3-merous, up to 3 cm long; tepals united in a filiform tube 5–7.5 cm long, hairy, limb 1–2 cm long, with 6 lanceolate yellow segments, nearly glabrous outside; stamens 6, free, inserted at the mouth of the perianth tube and half as long as limb; ovary inferior, cylindrical, 3-celled, densely hairy, stigmas 3. Fruit berry-like. Seeds turgid, seed coat crustaceous. *Curculigo* has been variously included in the *Amaryllidaceae* and the *Liliaceae*, but is nowadays usually considered as belonging to the comparatively small family *Hypoxidaceae*. *Curculigo* comprises about 10 species distributed in the tropics. Most species are also cultivated as ornamentals.

Ecology *Curculigo* species are shade-loving plants, thriving under partly shaded or sunless conditions, with abundant water supply. *Curculigo seychellensis* occurs frequently in damp shady forest in the Seychelles.

Management *Curculigo* species are propagated by seed, rhizome division or suckers.

Genetic resources and breeding It is not known to what extent *Curculigo seychellensis* is threatened with genetic erosion.

Prospects In view of its limited distribution and the availability of synthetic tying material, the role of *Curculigo seychellensis* as a fibre plant will remain limited to occasional local use in the Seychelles.

Major references Andre & Beaver, 2006; Baker, 1877; Robertson, 1989.

Other references Brink, 2003; Huxley (Editor), 1992a; Kirby, 1963; Nordal & Zimudzi, 2001.

Authors M. Brink

CUVIERA NIGRESCENS (Scott-Elliot) Wernham

Protologue J. Bot. 49: 321 (1911).

Family Rubiaceae

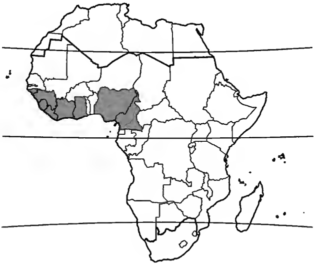
Chromosome number $2n = 44$

Synonyms *Vangueria nigrescens* Scott Elliot ex Oliv. (1894), *Cuviera trichostephana* K.Schum. (1897), *Cuviera minor* C.H.Wright (1906).

Origin and geographic distribution *Cuviera nigrescens* occurs from Guinea-Bissau eastward to southern Nigeria and Cameroon, and possibly in DR Congo.

Uses In Ghana the branches are split to make the ribs of umbrellas for chiefs. An extract of the root is applied as eye-bath against conjunctivitis.

Properties The wood fibres are 1.6–2.2 mm long.



Cuviera nigrescens – wild

Botany Shrub or small tree up to 12 m tall; bole up to 30 cm in diameter, bearing sharp spines; outer bark pale grey, inner bark green and brown; crown drooping; branches arching. Leaves opposite, simple, entire; petiole thin; blade elliptical to obovate, up to 13 cm × 5–8 cm, base rounded or attenuate, apex long-apiculate, glabrous except for a few hairs in axils of lateral veins, membranous, shiny, lateral veins in 6–7 pairs. Inflorescence an axillary spreading cyme with conspicuous pale bracteoles c. 8 mm long. Flowers greenish white, fragrant; calyx-lobes ovate-lanceolate, c. 3 mm × 8 mm, conspicuous, pale; corolla tube very short and hairy at base, lobes 5, lanceolate, apex pointed, with thread-like tips; anthers sessile; ovary rounded, 5-celled, ridged, styles glabrous, stigmas cylindrical. Fruit a drupe c. 4 cm in diameter, slightly 5-lobed when fresh, sharply 5-ridged when dry. Seeds kidney-shaped, with keel-like wings.

In Ghana *Cuviera nigrescens* flowers in February–May and fruits in June–October.

Cuviera is a genus of about 30 species, all in tropical Africa. A revision of the genus is lacking. It is possibly close to *Vangueriella*, but the group of *Vanguerieae*, in which *Cuviera* is classified, is in need of revision to elucidate the relationships between taxa.

Ecology *Cuviera nigrescens* occurs in moist primary forest and secondary vegetation.

Management *Cuviera nigrescens* is only collected from the wild.

Genetic resources and breeding The species is widespread and not threatened with genetic erosion.

Prospects *Cuviera nigrescens* is only used locally and its importance is unlikely to increase.

Major references Aubréville, 1959c; Burkill, 1997; Hepper & Keay, 1963; Irvine, 1961; Neuwinger, 2000.

Other references Alexandre, 1980; Fedorov, 1974; Lantz, Andreasen & Bremer, 2002; Lens et al., 2000a; Lens et al., 2000b; Muoghalu, Akanni & Eretan, 1993; Muoghalu & Okeesan, 2005; Nyerges, 1989; Unwin, 1920.

Authors L.P.A. Oyen

CYCLOSORUS INTERRUPTUS (Willd.) H.Itô

Protologue Bot. Mag. (Tokyo) 51: 714 (1937).

Family Thelypteridaceae

Chromosome number 2*n* = 72

Synonyms *Cyclosorus striatus* (Schum.) Ching (1941), *Thelypteris interrupta* (Willd.) K.Iwats. (1963), *Cyclosorus tottus* (Thunb.) Pic.Serm. (1968).

Vernacular names Willdenow's maiden fern, Willdenow's fern (En).

Origin and geographic distribution *Cyclosorus interruptus* has a pantropical distribution and is widespread in tropical Africa.

Uses The Ijo of the Niger delta use the leaves to make head-pads to carry loads. They also use the leaves for bathing, as sponge and soap substitute.

In Côte d'Ivoire a decoction of the plant is used as for washing sores. The plant is also used in preparations for the treatment of liver diseases, together with *Baphia nitida* Lodd. and *Centella asiatica* (L.) Urb. For the treatment of gonorrhoea, the leaves are soaked in water for 1–2 hours, after which the liquid is filtered and drunk.

In Papua New Guinea *Cyclosorus interruptus* is used for treating burns, cough, malaria and general sickness, A skin care product with cell activating and antioxidant properties based on *Cyclosorus interruptus* and *Thelypteris* species has been patented in Japan.

Properties In India, acetone extracts of the epidermal glands have shown antibacterial effects against *Salmonella typhi*.

A rare asymmetrical long-chain aliphatic ketone, 12-tritriacontanone, has been isolated from the plant. *Cyclosorus interruptus* also contains coumarin, furano-coumarin and dioxocane derivatives.

Botany Perennial fern with long-creeping rhizome. Rhizome 4–6 mm in diameter, chestnut-brown, glabrous, sparsely covered with scales; scales entire, narrowly ovate, 1–2.5 mm long, acute, black. Fronds spaced up to 12(–15) cm apart, 0.5–2.5 m long; stipe 45–90 cm long, pale brown, dark at base, glabrous; blade bipinnatifid with lower pinnae not reduced, oblong-lanceolate in outline, 30–85 cm × 25–30 cm, papery to slightly leathery, pinnae in 13–20 pairs, narrowly oblong, 10–21 cm × 1–2.5 cm, tapering towards apex, deeply to shallowly lobed, lobes ovate, quadrate or narrowly oblong, 6–17 mm × 4–7 mm, glabrous on both sides or pubescent beneath, margins hairy, often with sparse or many, distinct red glands and lattice-structured scales on underside of midrib of leaf and leaflets, veins raised beneath, basal ones merging with a vein along the margin of the lobe. Sori round and close together at first, later coalescing forming to form a characteristic U-shaped line around the sinuses between the lobes; indusium glabrous or densely hairy, sometimes with glands; sporangia on stalks with long hairs with a terminal, red gland.

Cyclosorus is a pantropical genus of about 3 species, but the number of species is disputed. Some authorities take a wider view of the genera *Cyclosorus* and *Thelypteris*; in the extreme view most species have been combined into a broad *Thelypteris*. In this view, the latter is a nearly cosmopolitan genus of about 875 species; subgenus *Cyclosorus* then comprises about 78 species.

Ecology *Cyclosorus interruptus* occurs from sea level up to 3150 m altitude, often in full sun. It is locally common in swamps and bogs especially along the edges, riverine bushland, in seepage areas in woodland, and in ditches and drains, for instance in sisal plantations. It has also been found on floating mats of vegetation in swamps or deep open marshes. It occurs sometimes is drier situations. The rhizome is often fully submerged.

Management *Cyclosorus interruptus* is only collected from the wild.

Genetic resources and breeding *Cyclosorus interruptus* is widespread and generally not in danger of genetic erosion. Locally, it is endangered, however, for instance in Réunion.

Prospects *Cyclosorus interruptus* will probably remain of occasional and local importance only.

Major references Adjanohoun & Aké Assi, 1979; Arantes, Prado & Ranal, 2007; Bouquet & Debray, 1974; Burkill, 2000; Verdcourt, 2006.

Other references Australian National Botanic Gardens, 2001; Cuidet et al., 2006; Hatani & Maeda, 2004; Holttum, 1971; Holttum, 1977; Neuwinger, 2000; Quadri-Spinelli, 1970; Quadri-Spinelli et al., 2000;

Tindale & Roy, 2002; Vincent & Kanna, undated.

Authors L.P.A. Oyen

CYPERUS LATIFOLIUS Poir.

Protologue Encycl. 7: 268 (1806).

Family Cyperaceae

Synonyms *Cyperus herana* Cherm. (1919).

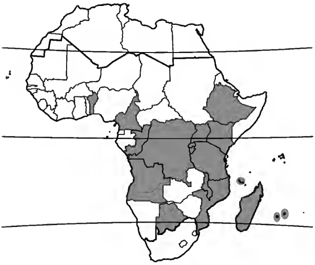
Vernacular names Epiphytic flatsedge (En).

Origin and geographic distribution *Cyperus latifolius* is widely distributed in tropical Africa, including Madagascar, and also occurs in South Africa and Swaziland. It is occasionally cultivated, for instance in Uganda and South Africa.

Uses The stems are widely used for thatching, for instance in Ethiopia, Uganda, Tanzania and Madagascar. In Kenya and Tanzania they are made into spirit houses. In Uganda the leaves are woven into mats. In Madagascar the leaves are used for weaving baskets, mats, hats and other products, and as cords. In South Africa and Swaziland the leaves are made into sleeping mats and a range of other plaited items, such as table mats, blinds, conference bags and folders.

Cyperus latifolius is one of the species planted in a wetland near Nairobi (Kenya), constructed to treat waste water. In Madagascar unspecified pant parts are used in the preparations of a black dye. In traditional medicine Uganda the root is used in the treatment of tuberculosis and related ailments.

Properties Air-dried material (moisture content 22%) used in pulping experiments in Kenya contained 16.4% lignin and 5.7% ash. After pulping with the soda process, a yield of 45% was obtained. The fibres in the unbleached and unbeaten pulp were on average 0.9 mm long and 18 μm wide. The resulting paper had good tensile, burst, fold and tear properties.



Cyperus latifolius – wild

Botany Perennial, robust herb up to 200 cm tall with 1–3 mm thick stolons covered with blackish scales; stems up to 160 cm tall, 3–8 mm wide, sharply 3-angled, usually slightly scabrid below the inflorescence, the basal part covered by leaf sheaths. Leaves in 3 vertical ranks; sheath slightly fleshy below, green to reddish brown, lowest sheaths bladeless and almost black; ligule absent; blade 40–260 cm × 8–30 mm, acute to acuminate at the apex, flat or v-shaped, glabrous or with scabrid margin and midvein. Inflorescence a large, terminal anthela 7–35 cm × 6–40 cm, consisting of 5–10 major branches, each with a usually 3-angled group of spikes; major involucral bracts leaf-like, usually spreading, up to 90 cm × 2 cm; major peduncles up to 35 cm long, somewhat flattened; spikes 10–40 cm × 10–40 cm, each with 5–20 spreading spikelets, rachis minutely hairy. Spikelets linear, 5–30 mm × 1–2(–3) mm, pale to dark red-brown, 5–30-flowered; glumes distichous, oblong-elliptical, 1.5–3 mm long, rounded at the apex, straw-coloured to pale or dark red-brown, with a green midvein and a colourless margin; flowers bisexual, perianth absent, stamens 3, ovary superior, 1-locular, stigmas 3. Fruit an obovoid nutlet up to 1.5 mm × 1 mm, 3-angled, papillose, pale brown when young, dark brown or grey when mature, 1-seeded.

Cyperus latifolius follows the C_4-cycle photosynthetic pathway. In a pure stand near Nairobi the aerial biomass was 2170 g/m^2. The canopy, with a Leaf Area Index of 15.3, intercepted more than 95% of the photosynthetically active radiation.

Cyperus comprises c. 550 species, mainly in the tropics and subtropics, and many of these are used for thatching and weaving.

Cyperus baronii C.B.Clarke is a herb with stems up to 90 cm tall, widely distributed in tropical Africa. In Madagascar its stems are used for weaving baskets, after the pith has been removed.

Cyperus grandis K.Schum., a perennial herb up to 200 cm tall only occurring in Kenya and Tanzania is recorded to be used for thatching in Tanzania.

Cyperus maranguensis K.Schum., a perennial herb up to 125 cm tall, distributed in Ethiopia, Kenya, Uganda and Tanzania, is used in basketry.

Cyperus marginatus Thunb. is a perennial herb up to 150 cm tall, distributed in Angola, Namibia, South Africa, Swaziland and Lesotho, and also recorded from Kenya. In Namibia the stems are used for thatching and for mat making. They have also been used for making baskets. The plant is grazed by livestock. In Namibia warmed portions of the root are placed as a poultice around the throat of someone with a sore throat or mumps. The plant is considered an indicator of the presence of water close to the soil surface. It is traded as an ornamental pond plant in South Africa.

Cyperus natalensis Hochst. ex C.Krauss ('giant dune sedge') is a perennial herb up to 130 cm tall, with leaf blades absent or up 10 mm long. It occurs in Mozambique and South Africa. The stems are woven into mats and other articles. It is sometimes grown as an ornamental plant.

Cyperus pangorei Rottb. is a perennial herb with stems up to 200 cm tall, distributed in South Asia and China. It has been cultivated in Mauritius, where it has been used for making mats and baskets. In Asia the stems are much used for weaving. The fibre cells in stems from India were on average 0.65–0.8 mm long and 9.4–9.9 μm wide. Processed stem strands obtained from mat weavers in Pathamadai (India) contained 83% holocellulose, 42% α-cellulose, 41% hemicellulose, 13% lignin and 1.7% waxes. *Cyperus pangorei* is a weed in rice fields.

Cyperus pectinatus Vahl (synonym: *Cyperus nudicaulis* Poir.) is a perennial herb with stems up to 120 cm tall and leaves without blades. It is widely distributed throughout tropical Africa, including Madagascar, and also occurs in South Africa and Swaziland. In Madagascar the stems are used for weaving hats, mats, baskets and boxes.

Cyperus procerus Rottb. (synonym: *Cyperus straminicolor* Cherm.), a perennial, stoloniferous herb up to 135 cm tall, is distributed in tropical Africa, tropical Asia and Australia. In Madagascar it is used for plaiting. In India the stems are used for making mats, and in Java they are used as string. *Cyperus procerus* is a weed in rice fields in Africa and Asia.

A range of *Cyperus* species endemic to Madagascar are used for plaiting. These include *Cyperus debilissimus* Baker, *Cyperus heterocladus* Baker, *Cyperus mangorensis* Cherm. (synonym: *Cyperus volodioides* Cherm.), *Cyperus nemoralis* Cherm. (synonym: *Cyperus onivensis* Cherm.), *Cyperus plantaginifolius* Cherm., *Cyperus volodia* Cherm. and *Cyperus xerophilus* Cherm. *Cyperus balfouri* C.B. Clarke (synonym: *Cyperus confusus* Cherm.), distributed in the Comoros, Mayotte, Madagascar and Réunion, is also used for weaving in Madagascar.

Ecology *Cyperus latifolius* occurs from sea-level up to 2100 m altitude in swampy locations, often on the drier margins of *Cyperus papyrus* L. swamps, in ditches along roads, and along streams. It is a weed in rice fields and pasture land.

Management In Uganda *Cyperus latifolius* is sometimes cultivated as a source of weaving material. In South Africa it has been planted in paddy fields to obtain material for weaving. In Madagascar weaving material is harvested year-round. When stems have been cut for the first time, the new leaves are finer than the original ones. The 1000-seed weight is 0.13–0.21 g.

Genetic resources and breeding *Cyperus latifolius* is widely distributed and common, even occurring as a weed, and is not threatened with genetic erosion, although it may suffer from general degradation of wetlands due to drainage and infilling for cultivation and construction.

Prospects *Cyperus latifolius* is a valued and widely used local source of material for weaving and thatching, sometimes even cultivated. It may have potential for the production of paper.

Major references Boiteau, Boiteau & Allorge-Boiteau, 1999; Burkill, 1985; Hoenselaar, Verdcourt & Beentje, 2010; Lye, 1997a; Nyakang'o & van Bruggen, 1999.

Other references Benazir et al., 2010; Cunningham, 1996; Decary, 1946; Haines & Lye, 1983; Jones, 1988; Murali, 1990; Rabarimanarivo, Jeannoda & Rabakonandrianina, 2005; SEPASAL, 1999; Tabuti, Kukunda & Waako, 2010; van den Eynden, Vernemmen & van Damme, 1992; Zwane et al., 2011.

Authors M. Brink

CYPERUS LIGULARIS L.

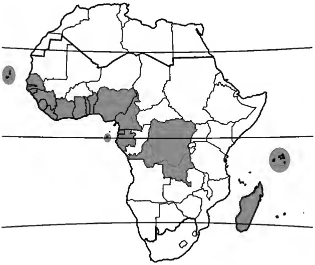
Protologue Syst. Nat., ed. 10, 2: 867 (1759).

Family Cyperaceae

Synonyms *Mariscus rufus* Kunth (1816), *Mariscus ligularis* (L.) Urb. (1900).

Vernacular names Swamp flat sedge (En).

Origin and geographic distribution *Cyperus ligularis* is distributed along the coast of



Cyperus ligularis – wild

West and Central Africa from Senegal to DR Congo. It also occurs in the Indian Ocean Islands and in South and Central America and the south-eastern United States.

Uses In Ghana the stems have been made into brushes which are used for applying whitewash to houses. In Brazil unspecified parts are a forage. *Cyperus ligularis* is sometimes grown as an ornamental plant.

Botany Perennial, tufted, glabrous herb with a short rhizome; stems up to 130 cm tall, (1–)4–6(–12) mm in diameter, in the upper part obtusely 3-angled in cross-section, papillose, base thickened and covered with persistent leaf sheaths. Leaves inserted in the lower part of the stem, in 3 vertical ranks; sheath 12–19 cm long; ligule absent; blade linear, 30–100 cm × 5–15(–20) mm, acuminate at apex, v-shaped, glaucous, margin and dorsal surface of midvein scabrid. Inflorescence an anthela (pseudo-umbel) with 5–12 rays of unequal length; rays up to 6(–16) cm long, each apically bearing a spike or a fascicle of 2–7 dense spikes; involucral bracts 4–8, leaf-like, spreading, up to 50(–80) cm long, attenuate at the apex; spikes ovoid to nearly cylindrical, 10–35 mm long, dark reddish brown, with many, tightly packed spikelets. Spikelets ovoid, 3–7(–10) mm × 1–2.5 mm, 2–4(–7)-flowered; glumes imbricate, ovate, 2–3 mm long, acute or obtuse at the apex, often tinged pink, midvein often green; flowers bisexual, perianth absent, stamens 3, ovary superior, 1-locular, stigmas 3. Fruit an obovoid nutlet c. 1.5 mm × 0.5 mm, 3-angled, attenuate at the apex, brown, 1-seeded.

In Senegal *Cyperus ligularis* flowers in September–November(–January). *Cyperus ligularis* follows the C_4-cycle photosynthetic pathway.

Cyperus comprises c. 650 species, mainly in the tropics and subtropics, and many of these are used for thatching and weaving. *Cyperus ligularis* and related species are sometimes classified in a separate genus *Mariscus*. *Cyperus tomaiophyllus* K.Schum. (synonym: *Mariscus tomaiophyllus* (K.Schum.) C.B.Clarke) is a very robust, perennial herb with stems up to 140 cm tall, occurring scattered in mountainous areas in West, Central and East Africa and Madagascar. It is used for thatching and is grazed by livestock.

Ecology *Cyperus ligularis* is a salt-tolerant species occurring usually near the sea, in the open or in light shade in swamps, marshes, creek margins, fringes of salt land and mangroves and moist depressions in coastal dunes, as isolated individuals or in populations of several square metres.

Genetic resources and breeding In view of its wide distribution *Cyperus ligularis* seems not liable to genetic erosion.

Prospects *Cyperus ligularis* is only occasionally used for making brushes, and its importance is unlikely to increase.

Major references Burkill, 1985; Lye, 1992; Simpson, 2006; Simpson & Inglis, 2001; Vanden Berghen, 1988.

Other references Akoègninou, van der Burg & van der Maesen, 2006; Ball, Reznicek & Murray (Editors), 2003; Clarke, 1901–1902; Haines & Lye, 1983; Hnatiuk, 1980; Hoenselaar, Verdcourt & Beentje, 2010; Hooper & Napper, 1972; Nelmes & Baldwin, 1952; Raponda-Walker & Sillans, 1961; Scholz & Scholz, 1983.

Authors M. Brink

CYPERUS PAPYRUS L.

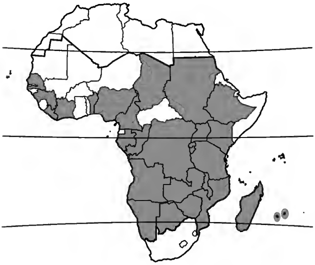
Protologue Sp. pl. 1: 47 (1753).

Family Cyperaceae

Chromosome number n = c. 50, $2n$ = c. 102

Vernacular names Papyrus, Egyptian paper plant, paper reed (En). Papyrus, souchet à papier, papier du Nil (Fr). Papiro (Po). Mafunjo, njaanjaa (Sw).

Origin and geographic distribution *Cyperus papyrus* originated in Central Africa and has spread over tropical Africa (including Madagascar). It has been cultivated in Egypt and neighbouring areas since ancient times and is sometimes naturalized in the Mediter-



Cyperus papyrus – wild and planted

ranean area. Nowadays it is widely grown as an ornamental.

Uses The pith of the stem was used by early civilizations (Egyptians, Greeks, Romans) to make a primitive form of paper, and the plant was cultivated for this purpose in the Egyptian Nile delta, Palestine and southern Europe. It was already in use by 3500 BC and fragments of papyrus sheets dated at 4600 years old have been found. The fibrous outer parts of the stem were used in ancient Egypt for making ropes, baskets, nets, sails, mats, sandals and furniture coverings. The stems were also made into boats and dried plant material served as fuel. The woody rhizome was used for making utensils and as fuel, while the pith was eaten raw or cooked and used for caulking boats.

Nowadays *Cyperus papyrus* is only cultivated on a small scale and used locally for mat-making and similar purposes. Papyrus stems or the fibre extracted from their outer layers also serve to make ropes, as thatching material, for sound isolation of metal roofs, and for construction and furniture. In the Lake Chad area the stems are made into canoes, rafts and watertight baskets. In Gabon the stems are woven into mats that are used as house partitions. After removal of the outer bark, they are cut into pieces and dried, and used for stuffing mattresses and cushions. Near Lake Victoria in Kenya papyrus is used principally to make mats from the stems, and in Uganda strips cut from the stems are woven into mats, carpets, baskets, fish traps and trays. In refugee camps in the Great Lakes region an innovative process has been developed for manufacturing sanitary napkins from papyrus pith, waste paper, and water. In Zambia the stems are locally used for construction and for making sleeping mats and screens. In Zimbabwe the fibrous outer part of the stem is used for making mats. In northern Botswana the stems are made into rafts and sleeping mats, and in Namibia into baskets and mats.

Many attempts at paper and board manufacture have failed, though there are successful examples of factories in Uganda and Rwanda utilizing papyrus to make cardboard and wallboard. Around 1920, a papyrus-based pulping mill operated for a short time in South Africa.

In Central Africa the pith of the old, dried stems is eaten. In southern Africa the lower part of the stem is eaten and the pith is chewed like sugar cane. The rhizome is edible as well. The plant is browsed by livestock. The dried rhizomes as well as the stems are used as fuel. In Burundi the ash of burnt plants has been used as a vegetable salt. *Cyperus papyrus* is planted worldwide as an ornamental, and the stems and inflorescences are used in floral arrangements.

Experiments indicate that the high biomass production of *Cyperus papyrus* makes it effective in removing N and P from wastewater and eutrophic pond water, and papyrus swamps serve as natural filters of sediment and pollutants and as shore stabilizers. The nutrient and pollutant-removal action of papyrus can be exploited in manmade waste-treatment ditches or constructed wetlands. Other environmental services of interest are potential carbon sequestration in the peaty sediments formed under papyrus swamps, though this peat is rapidly oxidized during periods of low water, hence releasing its stored carbon.

In traditional East African medicine the leaf is an ingredient of preparations used for the treatment of oedema.

In Uganda ash from the burnt inflorescence is used for the treatment of vaginal and rectal prolapse. In Tanzania a root decoction is taken together with the leaf sap of *Maytenus senegalensis* (Lam.) Exell for the treatment of female sterility. In Botswana the outer stem parts are used for making a cough remedy.

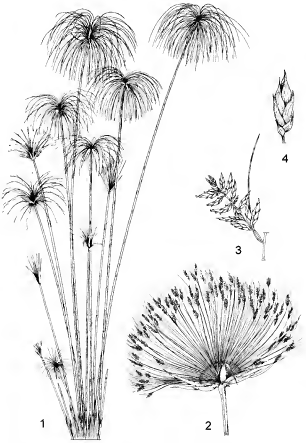
Production and international trade *Cyperus papyrus* is mostly used by the harvester or traded very locally, although some papyrus-derived handicrafts are sold to tourists.

Properties Ancient Egyptian papyrus sheets made from *Cyperus papyrus* have a characteristic grid pattern when backlit, due to the method of fabrication from one layer of strips laid side by side and another layer laid perpendicular to the first one. The pith used to make these papyrus sheets contains 54–68% cellulose and 24–32% lignin. Papyrus fibre cells are (1–)1.8(–4) mm long and (8–)12(–25) µm wide. They are narrow, thick-walled and have pointed ends. Investigations in the early 20th Century showed that papyrus stems from Egypt provided a moderate pulp yield of fair quality, but the pulp was difficult to bleach. Experiments with *Cyperus papyrus* in South Africa gave pulp yields of 45–48%. Because the stems have no nodes, the pulp does not contain hard particles, and even rayon-grade pulp has been produced from papyrus. However, the pith must be removed, as it does not add strength to the paper but uses pulping chemicals and makes washing and forming of the paper difficult. The pith is not a problem for the production of hardboard. More recently it has been found that the major pulping chemicals successfully pulp papyrus and the pulp can be bleached under conditions similar to those required for rice straw. The resulting pulp can be used as the main constituent of writing and printing papers, but not for wrapping paper.

According to a Kenyan study, juvenile umbels have a crude protein content of 11% and a ruminant digestibility of 38%, and mature umbels a crude protein content of 10% and a digestibility of 28%. Juvenile stems have a crude protein content of 4% and a digestibility of 45%, while mature stems have a crude protein content of 3.5% and a digestibility of 30%. These digestibility ranges compare favourably with common East African forage grasses, though it is not clear if papyrus would be a suitable forage to meet ruminant nutritional needs without supplementation. The great height of papyrus plants and the unsuitability of papyrus terrain for passage and grazing by heavy animals imply that its most plausible use would be as a chopped fodder to supplement protein-poor forages, especially in the dry season when grasses decrease in nutritional value. The alkaloids tyramine and octopamine have been recorded from the leaf.

Papyrus stems used as fuel produce a large amount of smoke and ash when burnt, and therefore they are rarely used in household cooking, but mostly in cottage industries such as for the preparation of beverages.

Description Robust, perennial herb with creeping rhizome; rhizome 2–6 cm thick, densely covered with black scales 5–10 cm × 5–10 cm; stems up to 5(–9) m tall, trigonous, green.



Cyperus papyrus – 1, habit; 2, inflorescence; 3, spike; 4, spikelet.
Source: Flore analytique du Bénin

Leaves in 3 vertical ranks, bladeless, except for sterile shoots; sheath 30–45 cm × 2–5 mm, the lowest ones much shorter. Inflorescence terminal, umbelliform, 30–60 cm × 30–80 cm; involucral bracts up to 12, lanceolate, major ones 5–18 cm × 1–3 cm, pale brown, never green; inflorescence branches 50–360 per stem, unequal, 5–40 cm × 1–1.5 mm, green, each with a simple umbel of 1–5 spikes; secondary bracts filiform, 4–12 cm long, green; spikes 15–30 mm × 6–12 mm, with 12–40 spreading spikelets. Spikelet cylindrical to slightly compressed, 3–12 mm × 0.5–1.5 mm, 5–17-flowered; glumes distichous, ovate, 1.5–2.5 mm long, pale brown with green midvein, the lower ones empty; flowers bisexual; stamens 3; ovary superior, stigmas 3. Fruit an ovate, trigonous nutlet c. 1 mm × 0.5 mm, grey, almost smooth.

Other botanical information *Cyperus* comprises c. 650 species, mainly in the tropics and subtropics.

Anatomy The stems are composed of a fibrous green outer skin surrounding a soft white pith. This pith is a mass of parenchyma cells surrounding hollow air ducts and rigid fibrovascular bundles. These fibrovascular bundles appear as dark lines in backlit Egyptian papyrus sheets. The air ducts contribute to stem buoyancy and are also involved in CO_2 recycling within the plant.

Growth and development A mature papyrus plant consists of stems of different maturity all arising from the same rhizome. Stems first elongate from this base with their umbel partially closed until they reach full height, at which point the umbel opens fully. Eventually mature stems senesce and die, leaving only a dry broken stump. The time from emergence of a new stem to death of that stem has been measured at 147 days at a highly productive site in Lake George (Uganda). The plant normally has no functioning leaves, instead carrying out photosynthesis through sterile umbel inflorescences adapted to the purpose (a typical stand of papyrus also has some stems with fertile umbels). The true leaves that accompany the early emergence and extension of new stems senesce under a mature canopy, because in a mature stand of papyrus little light reaches the base of plants. These leaves only serve as photosynthesizing organs during regrowth after cutting or burning of a papyrus stand, or in areas newly colonized by papyrus plants. In southern Africa flowering is in November–March.

Cyperus papyrus has C_4-photosynthesis, which contributes to its exceptionally high productivity. The stems have numerous large intercellular air cavities and 'Krantz' chlorenchyma, which are involved in CO_2-recycling. In natural swamps growth rates up to about 40 g/m^2 dry weight per day have been recorded, resulting in a theoretical annual production up to 145 t dry matter per ha, while in a constructed wetland in Uganda the annual production was 240 t per ha per year. In hydroponic culture short-term growth rates up to 125 g/m^2 dry weight per day are possible. In Lake Naivasha (Kenya) the total standing biomass was found to be 78 t dry matter per ha. Of this total biomass 57% was located in the rhizome, 1% in the roots, 29% in the stems and 13% in the umbels. In a study in Lake Victoria in Tanzania a total standing biomass of 151 t dry matter per ha was recorded, with 27% in the rhizome, 14% in the roots, 41% in the stems and 18% in the umbels.

Ecology *Cyperus papyrus* occurs from sea level up to 2500 m altitude in swamps and along the margins of lakes and rivers. It may form floating mats in open water, but is usually anchored by its rhizome in shallow water. It is adversely affected by seasonal flooding regimes exceeding 3–4 m in amplitude, flash flooding or very low water levels during the dry season. The plant is sometimes considered a nuisance, forming floating islands that obstruct navigation and water flow.

Cyperus papyrus is the dominant species in most African permanent swamps. It is estimated that monotypic and mixed papyrus swamps cover 40,000 km^2 in Central and East Africa alone. The Sudd wetland along the White Nile in Sudan is one of the world's largest wetlands and is dominated by *Cyperus papyrus*. Papyrus swamps serve to control nutrient and water flows for the associated bodies of water, filtering silt, nutrients, and pollutants from inflow, and moderating seasonal fluctuations in water level. They form a habitat for numerous species of birds, fish and aquatic mammals. In the Gaba swamp near Lake Victoria in Uganda the productivity of *Cyperus papyrus* is negatively affected by alum sludge discharges of a water treatment plant.

Papyrus grows year-round, with rapid uptake of nutrients and accumulation of biomass. Dead plants sink to anaerobic layers of the swamp and form a mass of peat. This peat serves as a carbon sink while submerged, but is rapidly decomposed and oxidized to release carbon dioxide gas when the water level falls dramatically, for example during the annual dry season. Annual carbon sequestration by a papyrus swamp in Lake Naivasha, Kenya has been estimated at 5–16 t per ha.

Propagation and planting *Cyperus papyrus* can be propagated by seed or rhizome pieces, with the latter most commonly used. The seeds need light to germinate.

Management The rhizome of planted *Cyperus papyrus* should be permanently submerged, though a saturated soil can also meet moisture requirements for the plant.

Harvesting Stems and rhizomes can be harvested year-round as the plant is a perennial with little seasonal variation in growth. However, in the Lake Bunyonyi region (Uganda) harvesting is concentrated in the dry season, perhaps because the swamps are more easy to enter when the water level is low, and around the beginning of each school semester, when households must pay school fees. Ecological studies indicate that annual harvest rates of 20% or more of the biomass reduce this biomass drastically over the long-term, so only 10–15% of the biomass should be taken annually for a sustainable exploitation.

Yield The aboveground production of *Cyperus papyrus* in Lake Naivasha swamp in Kenya has been estimated at about 50 t/ha dry matter per year.

Handling after harvest In ancient Egypt *Cyperus papyrus* was probably made into writing material by stripping the fibrous outer parts from the stems and slitting the inner pith into strips. These strips were laid side by side (and slightly overlapping), with a second layer of strips placed crosswise on top. This matrix of strips was then moistened, pressed together, sun-dried, and polished to make papyrus paper. Modern uses of the stems for thatch or crafts involve drying the stems or strips cut from the stems, and weaving or bundling these together.

Genetic resources *Cyperus papyrus* is widespread in Africa and elsewhere in the world, and reproduces both sexually and vegetatively, hence there is little risk of genetic erosion. However, it has almost entirely disappeared from the lower reaches of the Nile river, and the extent of many local papyrus swamps in Central and East Africa has diminished due to drainage and infilling for cultivation and construction, as well as water pollution and overharvesting of papyrus by the local population. In some parts of Kenya the area with papyrus swamps decreased by 50% between 1969 and 2000.

Breeding No breeding programmes of *Cyperus papyrus* are known to exist.

Prospects Although the cultivation of *Cyperus papyrus* is not important anymore, its value to the human communities surrounding natural papyrus swamps is extremely high. Figures on sustainable harvesting rates for cultivated papyrus do not exist, though if sustainable rates from natural swamps are an indicator, only 10% of standing biomass could be harvested any given year, giving potential annual yields of 1–14 t of stem biomass per hectare. This does not compare favourably with other common biomass producers such as maize, sorghum, or sugarcane. On top of this, use of papyrus as fuel gives much less economic benefit than craft production. For example, near Lake Bunyonyi (Uganda) 77% of harvested papyrus stems are used as fuel, even though a square-meter patch of cut stems earns US$ 0.13 if sold for use as fuel, compared to US$ 8 if made into baskets or hats. Hence to conserve papyrus resources and maximize economic benefit for users, it is desirable to shift use from fuel towards handicrafts and other high-value products, if there is a market.

Setting aside papyrus swamps for nature conservation or carbon sequestration may offer the greatest societal benefits on a worldwide scale, but unless there is direct compensation to the local people who depend on the swamps for economic activities, such a conservation-based ban on harvesting activities would greatly harm local welfare. An option would be to develop management plans to shift papyrus harvesting toward higher-value, lower-intensity uses such as crafts made from stems, paired with carbon-sequestration payments from the international community to the local populations managing these swamps sustainably.

Although *Cyperus papyrus* is no longer widely cultivated, industrial uses for paper pulp, specialty craft products, or even biomass fuel could encourage a resurgence in cultivation.

Major references Burkill, 1985; Dasuki, 2003; Gaudet, 1977; Ilvessalo-Pfäffli, 1995; Jones & Muthuri, 1985; Kipkemboi, van Dam & Denny, 2006; Lye, 1997a; Maclean et al., 2003a; Owen & Danzing, 1993; van Dam et al., 2007.

Other references Abe, Ozaki & Kihou, 1997; Baerts & Lehmann, 1989; Clarke, 1901–1902; Duke, 1983b; Hoenselaar, Verdcourt & Beentje, 2010; Hooper & Napper, 1972; Jones & Humphries, 2002; Jones & Muthuri, 1997; Kaggwa et al., 2001; Maclean et al., 2003b; Malaisse & Parent, 1985; Mena Lopez, 2002; Mnaya et al., 2007; Muthuri, 1992; Muthuri & Kinyamario, 1989; Owino & Ryan, 2007; Raponda-Walker & Sillans, 1961; Saunders, Jones & Kansiime, 2007; Simpson & Inglis, 2001; Weber, 1942.

Sources of illustration Akoègninou, van der Burg & van der Maesen, 2006.

Authors G. Vaughan

Based on PROSEA 17: Fibre plants.

DAIS COTINIFOLIA L.

Protologue Sp. pl. ed. 2, 1: 556 (1762).

Family Thymelaeaceae

Chromosome number $2n = 18$

Vernacular names Pompon tree, African button flower (En).

Origin and geographic distribution *Dais cotinifolia* is distributed in Tanzania, Malawi, Zimbabwe, South Africa, Swaziland and Lesotho. It was introduced into the highlands of Kenya and Tanzania as an ornamental. It has been planted in Europe since the 18th Century and was also introduced in other parts of the world.

Uses The fibrous bark has been used for tying and weaving and is plaited into strong rope. *Dais cotinifolia* has ornamental value and is frequently planted as an ornamental tree or shrub in East and southern Africa. A decoction of the leaf is drunk to treat stomach-ache in South Africa.

Properties The ultimate fibres in the bark are (2.8–)3.1(–3.5) mm long and (10–)12(–15) µm wide. The fibre is said to be very strong.

Botany Much-branched shrub or small tree up to 8(–15) m tall; crown rounded; branches dark or greyish brown, striate, glabrous. Leaves opposite or alternate, often at the ends of the branches, simple and entire; stipules absent; petiole (2–)4–6 mm long; blade broadly lanceolate to elliptical, (2.5–)3–9(–15) cm × (1.5–)2–5(–6.5) cm, apex acute to obtuse, more or less leathery, glabrous, with slightly bluish tinge above, pale green beneath, pinnately veined, with midvein and lateral veins yellow or pale green beneath and slightly raised. Inflorescence a dense terminal head up to 4 cm in diameter, 20–60-flowered; peduncle up to 8 cm long; involucral bracts (2–)4(–6), ovate to almost orbicular, 8–16 mm × 5–14 mm, outer ones largest, leathery, green, becoming chestnut brown or black, persistent. Flowers bisexual, regular, lilac, pink or white, fragrant; calyx tube cylindrical, often slightly curved, 10–30 mm long, silky hairy outside, less densely inside, lobes 5, narrowly ovate, unequal, 4–8(–10) mm × 1–2(–3) mm, hairy outside, less so inside; petals absent; stamens 10, in 2 whorls of unequal length, inserted on the calyx tube; ovary superior, 1-locular, style filiform, c. 22 mm long in short-styled flowers, 24.5 mm long in mid-styled flowers and 29 mm long in long-styled flowers. Fruit a dry nutlet, reddish brown, enclosed in the base of the persistent calyx tube. Seeds small, black, with crustaceous testa.

Dais cotinifolia grows fast; in South Africa trees reach their full height within 4–5 years. Flowers are produced on the previous year's growth. They are cross-pollinated. In southern Africa flowering is in November–February and fruiting in January–April.

Dais comprises 2 species, with *Dais glaucescens* Decne. ex C.A.Mey. being endemic to Madagascar.

Ecology *Dais cotinifolia* occurs at 1200–2300 m altitude in margins of evergreen forest, in grassland, along streams and on rocky mountain sides. It is fairly resistant to drought. Young trees need to be protected from frost for their first two years, but older trees are frost-hardy.

Management *Dais cotinifolia* is easily propagated by seed or cuttings. It can be pruned. *Dais cotinifolia* is recorded to be susceptible to pink disease, caused by *Corticium salmonicolor* (synonym: *Erythricium salmonicolor*). Symptoms include branch and stem die-back due to girdling cankers, which are characterized by gum exudation, cracking of the bark due to death of the cambium, and abundant pink mycelial growth.

Genetic resources and breeding In southern Africa trees are destructively harvested for their bark, but there are no reports that *Dais cotinifolia* is threatened by genetic erosion.

Prospects The bark fibre of *Dais cotinifolia* is strong and can be made into rope of excellent quality. However, detailed, quantitative information on the fibre properties is scarce, and research in this area is warranted.

Major references Coates Palgrave, 1983; Peterson, 1978; Peterson, 2006; van Wyk & Gericke, 2000.

Other references Bhat, 1998; Huxley (Editor), 1992b; Hyde & Wursten, 2009a; Lovett et al., 2006; Medina, 1959; Pienaar, 2003; Roux & Coetzee, 2005; van der Walt, 2000; van Wyk & van Wyk, 1997; Zavada & Lowrey, 1995.

Authors M. Brink

DAIS GLAUCESCENS Decne. ex C.A.Mey.

Protologue Ann. Sci. Nat., Bot., sér. 2, 20: 51 (1843).

Family Thymelaeaceae

Synonyms *Dais cotinifolia* Lam. non L.

Origin and geographic distribution *Dais glaucescens* is endemic to Madagascar, where it occurs from the northern to the southern part of the island.

Uses *Dais glaucescens* is one of the species of which the bark has been used since long for making 'Antaimoro paper', a paper of excellent quality, which is now made into articles such as stationary, envelopes, cards, notebooks, photo albums, lampshades and gift bags. The bark is used for the manufacture of string, and was formerly used for making barkcloth. The bark fibre can be woven into textiles. The white-coloured wood is suitable for boxes.

Botany Small tree up to 8 m tall; bole up to 25 cm in diameter; branches striate, glabrous. Leaves opposite, simple and entire; stipules absent; petiole 4 mm long; blade ovate, 5–6 cm

× 3–3.5 cm, apex obtuse, glabrous. Inflorescence a dense head, 10–12-flowered; peduncle up to 3 cm long; involucral bracts 4–5, ovate, 5 mm × 3 mm, hairy. Flowers bisexual, regular, 15–18 mm long, white hairy, orange to yellow-orange; calyx tube cylindrical, broad, often curved, lobes 5, petals absent; stamens 10, in 2 whorls, the longer ones slightly exserted; ovary superior, 1-locular. Fruit unknown.
Dais glaucescens flowers in March.
Dais comprises 2 species, with *Dais cotinifolia* L. distributed in East and southern Africa.

Ecology *Dais glaucescens* occurs in forest, particularly littoral forest, and on bare mountains and near water.

Management 'Antaimoro paper' was introduced into Madagascar by Arabs who settled on the east coast of Madagascar. The process of making 'Antaimoro paper' was kept a secret until 1936, when a French planter, Pierre Mathieu, began collaborating with the descendants of the first Arab settlers. 'Antaimoro paper' is still handmade in small paper factories, using the ancient methods. The bark is soaked and pounded into a pulp with wooden mallets, after which the pulp is laid on a screen, imbedded with dried flowers, and placed in the sun to dry.

Genetic resources and breeding It is difficult to assess whether *Dais glaucescens* is threatened by genetic erosion, as information is lacking on its precise distribution within Madagascar.

Prospects Little information is available on *Dais glaucescens* and its fibre properties. Its use in the niche market for high-quality 'Antaimoro paper' may increase with increasing tourism to Madagascar.

Major references Boiteau, Boiteau & Allorge-Boiteau, 1999; Decary, 1946; Leandri, 1950.

Other references Borris, Blasko & Cordell, 1988; Schatz, undated; Zavada & Lowrey, 1995.

Authors M. Brink

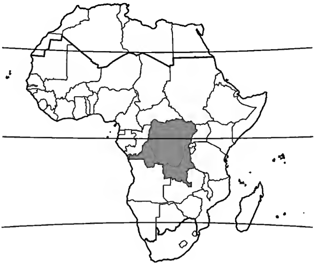
DEINBOLLIA PYNAERTII De Wild.

Protologue Ann. Mus. Congo., Bot., sér. 5, 3: 111 (1909).

Family Sapindaceae

Origin and geographic distribution *Deinbollia pynaertii* is endemic to DR Congo.

Uses The bark is used for making straps, and the pulp of the fruits is locally eaten.



Deinbollia pynaertii – wild

Botany Monoecious, single-stemmed, small tree up to 3–4 m tall; bole up to 12 cm in diameter. Leaves alternate, paripinnately compound with 6–11 pairs of leaflets, up to 1 m long, glabrous; petiole 10–20 cm long; rachis 20–50 cm long, grooved; petiolules 3–5 mm long; leaflets alternate or subopposite, oblong-elliptical or ovate, 8–35 cm × 4–15 cm, margin entire. Inflorescence a much branched panicle, axillary or terminal, up to 45 cm × 20 cm. Flowers unisexual; pedicel 1.5 mm long; sepals 5, with white hairs on outside, free, imbricate; petals 5, white, 3–4 mm long, margin long ciliate; stamens c. 14, 4–5 mm long in male flowers, 2 mm long in female ones; ovary superior, 1 mm in diameter and 3-lobed in female flowers, absent in male flowers. Fruit an indehiscent capsule, 10–14 mm in diameter, orange, 1-seeded. Seedling with hypogeal germination; first 2 leaves opposite.
The genus *Deinbollia* is restricted to sub-Saharan Africa and Madagascar and comprises 30–40 species. Many of the taller species are used as sources of timber.

Ecology *Deinbollia pynaertii* is found in dense upland forest and swamp forest.

Prospects There apparently is little interest in *Deinbollia pynaertii* and the plant will probably remain of local importance only.

Major references Hauman, 1960; Martin, Campbell & Ruberté, 1987.

Other references De Wildeman, 1919; Fouilloy & Hallé, 1973.

Authors C.H. Bosch

DESPLATSIA SUBERICARPA Bocq.

Protologue Adansonia 7: 51 (1866).

Family Tiliaceae

Origin and geographic distribution *Desplatsia subericarpa* is distributed in West and Central Africa, from Sierra Leone to DR Congo and Cabinda (Angola).

Uses The fibrous bark is used in DR Congo for making rope. The leaves have been recorded to be eaten as a leaf vegetable in Nigeria, whereas other sources mention they have been used for poisoning. In Ghana and Gabon the ripe fruit is boiled to obtain a black dye, derived from an orange-red gum present in the fruit. The dye is used for cloth and stains like printer's ink. The fruit is recorded to be eaten as a vegetable in Nigeria, and it is rubbed on the body to prevent animals from biting.

Botany Shrub or small tree up to 10 m tall; bole 4–10 cm in diameter; branchlets densely reddish hairy to glabrescent. Leaves alternate, simple; stipules 3–6-fid, 4–9 mm long, with linear-filiform lobes, hairy, persistent; petiole 5–20 mm long, hairy; blade ovate-oblong to obovate-oblong, 7–25 cm × 2.5–9.5 cm, base cordate to subcordate and asymmetric, apex long-acuminate, margin obscurely toothed, pinnately veined with 8–50 pairs of lateral veins, papery, glabrous above except for the sparsely hairy veins, sparsely hairy below. Inflorescence composed of axillary or terminal umbelliform cymes, slender, lax, 3–7-flowered; peduncle 0.5–4.5 cm long, hairy; involucral bracts 3–4-fid, 4–6 mm long, with linear-filiform lobes, hairy, more or less persistent. Flowers bisexual, regular, 5-merous; pedicel 4–10 mm long; sepals oblanceolate, 8–10 mm × 2–3 mm, fringed at the apex, hairy on both sides; petals oblong, 1.5–3 mm × 2–3 mm, rounded at the apex, pinkish white, hairy outside; stamens numerous, connected at the base in a glabrous tube; ovary superior, 5–7-celled. Fruit an oblong-ellipsoid drupe 6–10 cm × 5–7.5 cm, glabrous, surface uneven, yellow at maturity, containing a gum changing from yellow through orange and red to black, many-seeded. Seeds ovoid, winged. Seedling with epigeal germination; first leaves opposite, simple, toothed.

In Ghana *Desplatsia subericarpa* flowers in November–March. In Côte d'Ivoire it fruits in July.

Desplatsia comprises 4–6 species, distributed in tropical Africa.

Ecology *Desplatsia subericarpa* occurs from sea-level up to 600 m altitude, in the understorey of dense, evergreen, often secondary forest, and along rivers. It is common in Ghana.

Management The 1000-seed weight of *Desplatsia subericarpa* is 165–200 g. In Côte d'Ivoire germination takes 15–30 days.

Genetic resources and breeding *Desplatsia subericarpa* has a wide distribution, and is not threatened by genetic erosion.

Prospects *Desplatsia subericarpa* is a local source of fibre, dye and food, but it seems not important in any of these aspects and is unlikely to become more important in the future.

Major references Aubréville, 1959a; Burkill, 2000; de la Mensbruge, 1966; Wilczek, 1963.

Other references Hawthorne, 1995; Irvine, 1961; Johnson & Johnson, 1976; Keay, 1958h; Masters, 1868b; Neuwinger, 2000; Raponda-Walker & Sillans, 1961.

Authors M. Brink

DICRANOPTERIS LINEARIS (Burm.f.) Underw.

Protologue Bull. Torrey Bot. Club 34: 250 (1907).

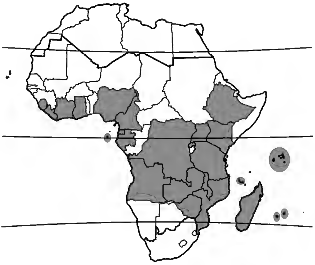
Family Gleicheniaceae

Chromosome number $2n = 78$ (diploid), 117 (triploid), 156 (tetraploid)

Synonyms *Gleichenia linearis* (Burm.f.) C.B.Clarke (1880).

Vernacular names Scrambling fern, false staghorn (En).

Origin and geographic distribution *Dicranopteris linearis* is distributed from Sierra Leone eastwards to Ethiopia and Kenya and southwards to Angola, Zimbabwe, Mozambique and most of the Indian Ocean Islands. It also occurs in South Africa and from Asia to Aus-



Dicranopteris linearis – wild

tralasia and Polynesia (including Hawaii), and is recorded in Brazil as well.

Uses In DR Congo the leaf axes are used to make a basket-type trap for fishes and are plaited for the construction of local beds. In Gabon the hollow stems are used as straws for drinking palm wine and children use them as toy blowpipes. For Asia a larger number of uses of the fibres have been recorded, such as plaiting, basketry, ropes, caps, arm bands and belts. As the fibres are fairly salt resistant, they are widely used for making fish-traps.

Dicranopteris linearis is sometimes planted to prevent soil erosion and in nursery gardens the cut leaves are put upright in the soil to temporarily provide young seedlings with shade. Medicinal use includes external application of a poultice of crushed leaves to combat fever and for wound dressing. It is also used as an anthelminthic. A decoction is drunk in Thailand against insomnia and to bathe children with skin rash and people with a broken leg. In Hawaii a plant extract is drunk as a cure for constipation. Further problems treated are: chest complaints, bruises, burns, sprains, itching, gonorrhoea and infertility.

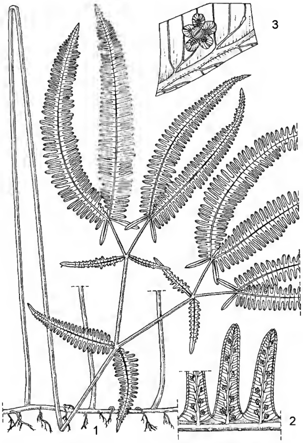
Production and international trade Production is only locally important in tropical Africa. Early in the 20th century, Malaysia exported vigorous petioles to India on a small scale. In Asia the use *Dicranopteris linearis* fibre is dying out as the ready-for-use fibres for matting and weaving have become very expensive.

Properties The leaves contain tannins (3.8%), essential oils (0.03%) and saponins, as well as clerodane glycosides. Flavonoids are limited to flavonol 3-O-glycosides like afzelin, quercitrin, isoquercitrin, astragarin, rutin and kaempferol.

Dicranopteris linearis is able to accumulate relatively high concentrations of rare earth elements, especially in the roots (Eu, Gd, Ho, Pr, Sm, Y) and the leaves (Ce, Dy, La, Nd, Tb).

Tests in the Philippines revealed that water extracts showed positive antimicrobial activity against *Micrococcus luteus* and *Escherichia coli*. In Malaysia leaf extracts were found to possess antinociceptive, anti-inflammatory, antistaphylococcal and antipyretic activities with the methanolic extracts as the most potent among the extracts.

Botany Terrestrial fern, up to 3 m tall, with dichotomously divided leaves; rhizome several m long, up to 5 mm in diameter, creeping, brown, covered with septate, branched hairs. Leaves appearing on rhizome, 6–20 cm apart; petiole erect, stout, glabrous, up to more than 1 m long, brown to purplish; lamina large, in outline kidney- or halfmoon-shaped, 60–200 cm long, 2–3-furcate with only the ultimate branches bearing pinnae, a dormant bud in each bifurcation and a pair of stipule-like branches present at the base of each bifurcation; pinnae narrowly lanceolate, deeply pinnatifid, assymetrical at base, more reduced towards the apex; ultimate segments 18–40(–70) mm × 3–5 mm, confluent at the broadened base. Sori superficial, in a median row on each side of the midrib, almost round, 1 mm in diameter; sporangia without indusia. Spores trilete, tetrahedral with prolonged angles, somewhat wrinkled.



Dicranopteris linearis – 1, habit; 2, some fertile ultimate leaf segments; 3, sorus.
Source: PROSEA

The genus *Dicranopteris* comprises c. 12 species. *Dicranopteris linearis* is a very variable species. In South-East Asia 13 varieties are distinguished mainly based on the mode of branching, and supported by differences in flavonol or flavone content. The existence of triploid hybrids makes it hazardous to assign a plant to a clearly defined variety.

Ecology *Dicranopteris linearis* occurs from sea-level up to 2800 m altitude on open and shaded slopes, roadsides, in humid montane forests, evergreen bushland and secondary woods. It can colonize sites and remain dominant for a long time with its mat-forming capacity and leaves with low decomposability. Its quick establishment helps to prevent landslides on cleared slopes but at the same time can make it a noxious weed. It is well adapted to soils poor in phosphorus.

Management *Dicranopteris linearis* is propagated best by planting rhizome pieces in soil exposed to full sun. Raising plants from spores is troublesome. After harvesting, the leaf axes are cut longitudinally into 4 strips, are soaked in water for a week and are rubbed with coconut oil to obtain a black colour. Plaiting must be done when the strips are still wet as dry ones are too brittle.

Genetic resources and breeding *Dicranopteris linearis* is widely distributed and does not seem to be in danger of extinction or genetic erosion.

Prospects The use of *Dicranopteris linearis* for its fibres is declining as cheaper alternatives are available. The medicinal uses and properties deserve further investigation. Where it is considered a troublesome weed, research on control measures is a priority.

Major references Raponda-Walker & Sillans, 1961; Titien Ngatinem Praptosuwiryo, 2003; Verdcourt, 2000; Yamada, 1999.

Other references Burkill, 2000; Ho et al., 2010; Raja et al., 1995; Sebsebe Demissew, 2009; Umi Kalsom Yusuf, 1995; Zakaria et al., 2010.

Sources of illustration Titien Ngatinem Praptosuwiryo, 2003.

Authors C.H. Bosch

Based on PROSEA 15(2): Cryptogams: Ferns and fern allies.

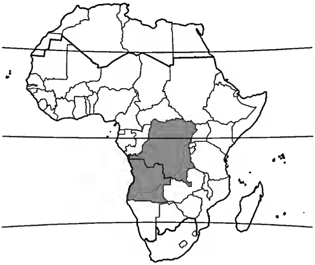
DIOSPYROS HETEROTRICHA (B.L.Burtt.) F.White

Protologue Bull. Jard. Bot. Etat 33: 365 (1963).

Family Ebenaceae

Synonyms *Diospyros loureiriana* var. *heterotricha* Welw. ex Hiern (1875), *Royena heterotricha* B.L.Burtt (1935).

Origin and geographic distribution *Diospyros heterotricha* occurs in DR Congo and Angola. It is probably introduced and cultivated for its fruit in northern DR Congo and West Africa.



Diospyros heterotricha – wild and planted

Uses The twigs and roots are used as chew-sticks. The wood becomes brown in contact with the air and is sometimes used in preparations to colour the lips. The fruits are eaten. *Diospyros heterotricha* is closely related to *Diospyros loureiriana* G.Don, an important dye plant distributed from Kenya to Mozambique, and it is likely that its roots are similarly used.

Properties Extracts of the root bark and root have shown antibacterial activity. Several naphthoquinones were identified in a trichloromethane extract of the powdered root bark, including 8'-hydroxyisodiospyrin, 7-methyljuglone, 2-methylnaphthazarin, 8,8'-dihydroxy-4,4'-dimethoxy-6,6'-dimethyl-2,2'-binaphthyl-1,1'-quinone, and 5,8-dihydroxy-2-methyl-1,4-naphthoquinone.

Botany Dioecious shrub or small tree up to 8 m tall, but usually much smaller and sometimes up to only 0.5 m tall; young branches covered with short bristle-like and long hairs and sparse glands. Leaves alternate and entire; blade obovate, 5–10 cm × 2–4.5 cm, base rounded, apex shortly acuminate, lower surface with long and short hairs mainly on veins. Flowers axillary, unisexual, female flowers solitary, male flowers 2–3 together in long-pedunculate cymes; pedicel c. 10 mm long; calyx c. 3 mm long, deeply and irregularly 4(–5)-lobed, lobes triangular to ovate, with white-hairy, reduplicate margins, moderately accrescent; corolla campanulate, c. 4 mm long, deeply 4(–5)-lobed, lobes at first a continuation of corolla-tube, then spreading or reflexed, white; male flowers with 8(–10) slightly exerted stamens c. 3 mm long inserted at base of corolla, pistillode resembling pistil but without stigmas; female flowers with 8 staminodes 1.5 mm long, and an ovoid-conical, 8-celled ovary c. 2 mm in diameter, with 4 styles ending in bilobed stigma. Fruit an obovoid berry, 10–18 mm in diameter, yellow to slightly orange, very short-hairy, with persistent, almost leaf-like calyx-lobes 10–16 mm long, up to 8-seeded. Seed c. 1 cm long, dark reddish brown.

Diospyros is a large pantropical genus of about 500 mostly tropical species. In continental tropical Africa, about 90 species occur, several of which produce valuable timber or edible fruits; in Madagascar also about 90 species occur.

Ecology *Diospyros heterotricha* occurs from sea-level up to up to 1000 m altitude in *Terminalia* forest, secondary forest, savannah, grassland and fallow land. It is probably an obligate light-demanding species of early secondary vegetation.

Management *Diospyros heterotricha* is occasionally cultivated for its fruit.

Genetic resources and breeding There are no indications that *Diospyros heterotricha* is in danger of genetic erosion.

Prospects *Diospyros heterotricha* is likely to remain a valuable source of chew-sticks and fruit.

Major references Alves, Cruz Costa & Ferreira, 1973; Burkill, 1994; Latham, 2004; White, 1963a; White, 1987.

Other references Ferreira, Cruz Costa & Alves, 1972; Ferreira, Alves & Figueira de Sousa, 1972; Ndouga et al., 1991; Neuwinger, 2000; White, 1963b; White, 1978.

Authors L.P.A. Oyen

DIOSPYROS LYCIOIDES Desf.

Protologue Ann. Mus. Natl. Hist. Nat. 6: 448 (1805).

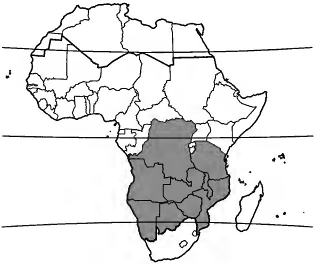
Family Ebenaceae

Chromosome number $2n = 30, 60$

Vernacular names Bluebush, bluebush star-apple, red star-apple, monkey plum, African persimmon (En). Plaqueminier élégant (Fr).

Origin and geographic distribution *Diospyros lycioides* occurs in Central Africa, southern Tanzania, throughout southern Africa, including South Africa, Lesotho and Swaziland, but excluding the winter-rainfall area. It is occasionally cultivated in South Africa and elsewhere in the tropics. In Australia it also naturalized and categorized as a weed.

Uses Pieces of root of *Diospyros lycioides* are widely and commonly used as toothbrush, and pieces of the stem are used similarly in some areas. The small-sized wood is mainly suitable for small items of furniture and carvings such as trinket boxes, spoons and handles for tools and implements. Occasionally the wood is used in hut construction, especially where smaller branches are needed. It is also used for fencing and as fuel. The leaves are important browse for both domestic and wild animals, although it is said to taint the milk of cows. In southern Africa the fruit and seed are used as food and are also used to make beer. Fruits are also fermented to distil alcohol. The roasted ground seeds were once used as a coffee substitute. A yellowish brown dye is obtained from the roots while the bark is used for tanning skins. In Botswana the dye is used to colour palm leaves for basketry. The plant is a bee forage. In South Africa and some parts of Europe, *Diospyros lycioides* is planted in gardens and used in landscaping.


Diospyros lycioides – wild and planted

The roots are used medicinally by local people. The root is chewed for the treatment of colds and coughs. The powdered root or a root extract is used against eye ailments. The roasted and powdered root mixed with mutton fat makes a thorn plaster and is used to ease body pain. The powdered root bark is used as an abortifacient; it is also rubbed into scarifications to treat patients with pneumonia or snake-bites. Root decoctions are held in the mouth to allay toothache or gargled against a sore throat, and they are drunk against female infertility, blood in the stool, abdominal pain, body pain, cardiac pain, and epilepsy. Root decoctions are taken against dysmenorrhoea and form part of a medicine given to vomiting babies. The root decoction and the raw fruit are considered to be effective against tuberculosis. In South Africa decoctions of the root mixed with those of *Cassia petersiana* (Bolle) Lock and *Euclea natalensis* A.DC. are eaten with sheep or goat meat to treat epilepsy and asthma.

The Venda people use *Diospyros lycioides*, mixed with *Gardenia* sp., to appease the spirit of a young man who has died before marriage. In times of war they use parts of this tree mixed with hedgehog prickles and duiker blood to provide protection against enemies. In Zimbabwe and Malawi pieces of root are buried in the corners of the house as protection against witchcraft.

Production and international trade The fruits are traded locally in southern Africa. In Australia *Diospyros lycioides* is a quarantined weed which requires assessment before entry into the country. There are no restrictions on its importation in the United States.

Properties Chewing the root gives the teeth a yellow colour. In a health survey in Namibia users of *Diospyros lycioides* toothbrushes were found to have less caries than non-users. Early analyses of extracts of the leaves and young twigs yielded lupeol and ursolic acid. Later, methanol extracts of the twigs were found to inhibit growth of several common oral pathogens, including *Streptococcus mutans*, *Streptococcus sanguinis*, *Prevotella intermedia* and *Porphyromonas gingivalis* which supports their use as chewing sticks. The bactericidal effect has been attributed to several naphthalene glycosides (named diospyrosides), bi-naphthalenone glycosides, and the naphtoquinones juglone and 7-methyljuglone. Methylnaphthazarin, mamegakinone and 8'-hydroxyisodiospyrin have been identified in a trichlormethanol extract of the powdered root bark.

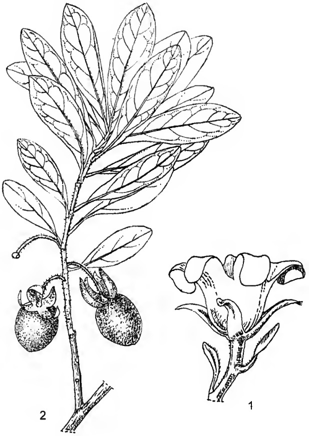
The heartwood of *Diospyros lycioides* is pink-brown and distinct from the paler sapwood. The wood is moderately durable. It is resistant to impregnation and tends to warp if not properly stacked and dried slowly. It saws cleanly and holds nails well. It planes to a fairly smooth finish. It takes paint and varnish well and glues firmly. The wood sands and polishes well. Mechanical strength and shrinkage values not known. Weight at 12% moisture content is about 750 kg/m^3. The commercial availability of timber is restricted due to small size.

The fruit pulp contains per 100 g: water 78.0 g, energy 296 kJ (71 kcal), protein 0.9 g, fat 0.1 g, carbohydrate 16.5 g, crude fibre 3.5 g, Ca 66.8 mg, Mg 39.7 mg, P 13.7 mg, Fe 1.0 mg, Zn 0.3 mg, thiamin 0.11 mg, riboflavin 0.09 mg, niacin 0.17 mg, ascorbic acid 45.2 mg (Wehmeyer, 1986). The fruit is not very popular; it may be slightly poisonous for humans.

In South Africa the nutritional value of the browse was analyzed. Leaves contain 12–14 g crude protein per 100 g dry matter, twigs 7.6 g when 2 mm in diameter, 4.6 g at 10 mm diameter and further declining with thickness. Another analysis indicated that the leaves contain per 100 g dry matter 12.5 g crude protein and 54,4 g neutral detergent fibre (NDF), and the twigs 5.7 g crude protein and 64,2 g NDF. Poisoning has been recorded in sheep after they had eaten the leaves and fruits. Alkaloids have been detected in the leaf. Extracts of stem and leaves have shown dose-dependent anti-inflammatory effects by suppressing cyclooxyenase enzymes.

The tough roots rapidly blunt ploughs and other tools.

Description Dioecious shrub or small tree up to 7 m tall, sometimes much smaller; bole sometimes spinescent towards the base; bark



Diospyros lycioides – 1, male flower; 2, fruiting branch.
Redrawn and adapted by Iskak Syamsudin

grey, more or less smooth. Leaves clustered at the ends of branches, simple and entire; petiole 3–15 mm long; blade obovate to oblanceolate, 1.5–8 cm × 0.5–3 cm, base cuneate, apex broadly tapering to rounded to acute, margin entire and tightly rolled under, papery to leathery, drying dull green or grey-green above, paler beneath, lower surface sparsely to densely silky hairy when young, hairs sometimes persistent, especially on the veins, midrib and lateral veins not prominently raised, secondary veins in 5–6 pairs. Flowers solitary in axils of leaves or reduced leaves towards base of current year's growth, 8–15 mm in diameter, pendulous, creamy white, fragrant; pedicel slender, up to 3 cm long; calyx up to 8 mm long, deeply cleft into 5 lobes, densely silky hairy, lobes narrowly deltate or lanceolate-acuminate; corolla up to 1 cm. long, bell-shaped, widely open at the throat, densely strigulose outside, lobed to just below the middle, lobes 5, ovate-oblong, obtuse; male flower with 10 stamens 3–4.5 mm long, with glabrous filaments and narrowly lanceolate, apiculate, densely setose anthers, pistillode similar to functional pistil but with reduced styles and lacking stigmas; female flower with 10 densely setose staminodes 1–2 mm long, ovary subglobose, 2.5 mm × 2.5 mm, ridged, tomentellous, 6, 8 or 10-celled, styles (3–)5, common part puberulous, style-branches glabrous, ending in a shallowly bilobed stigma. Fruit an ovoid or globose berry up to 2 cm × 1.5 cm, apiculate, red, becoming black, downy hairy or glabrescent, persistent calyx accrescent, up to 1.5 cm long, lobes narrowly deltate and ultimately strongly reflexed, 1–6-seeded. Seeds up to 13 mm long, brown, smooth.

Other botanical information *Diospyros* is a large pantropical genus of about 500 tree species. Most of them are native to the tropics, with only a few species extending into temperate regions. In tropical Africa, about 90 species occur, several of which produce valuable timber or edible fruits; in Madagascar also about 90 species occur. Phylogenetic evidence indicates that *Diospyros* section *Royena* is a distinct, monophyletic group of closely related species. It has been considered a separate genus, but most authorities retain it as a section of *Diospyros*.

In *Diospyros lycioides* 4 subspecies are recognized differing mainly in leaf form and distribution:

- subsp. *lycioides* (synonym: *Royena lycioides* (Desf.) A.DC.; vernacular name: Karoo bluebush): shrub or small tree up to 7 m tall; branchlets spreading at right angles or slightly ascending at the ends, occasionally spinescent; leaves crowded towards the tips, blade up to 4 cm × 1.5 cm, glabrous or slightly velvety, lateral veins not raised. It is mainly found in Botswana, Zimbabwe and the drier parts of Namibia and South Africa, in riparian forest and thicket at 600–1000(–2700) m altitude.
- subsp. *guerkei* (Kuntze) De Winter (synonym: *Royena guerkei* Kuntze; vernacular names: quilted bluebush, eastern bluebush, Natal bluebush): shrub or small tree up to 5 m tall; branchlets ascending, not spinescent; leaves not crowded, blade 2–5 cm × 1–2 cm, distinctly net-veined. It occurs in Botswana and north-eastern South Africa, in rocky habitats, often associated with quartzite outcrops, from sea-level up to 2150 m altitude.
- subsp. *nitens* (Harv. ex Hiern) De Winter (synonym: *Royena nitens* Harv. ex Hiern; vernacular name: silvery bluebush): small, multi-stemmed shrub up to 1.5 m tall; leaf blade small, up to 2 cm × 1 cm, densely covered with silvery hairs. It occurs in north-eastern South Africa, in dry, hot bushveld, grasslands and rocky outcrops, from sea-level up to 1550 m altitude.
- subsp. *sericea* (Bernh.) De Winter (synonym: *Royena sericea* Bernh.; vernacular names: eastern bluebush, Kalahari star apple, hairy bluebush, Natal bluebush): shrub or small tree up to 7 m tall; branchlets usually ascending, with the leaves inserted more or less evenly along their length, rarely spinescent; leaf blade up to 8 cm × 3 cm, densely hairy. It is distributed from Upper Shaba in DR Congo and Angola southwards to Namibia and eastern Cape Province in South Africa, occurring from sea-level up to 2000 m altitude in bushland and thicket, especially on riverbanks and termite mounds and in rocky locations, sometimes at edges of riparian forest or forming secondary thickets following over-grazing.

Growth and development Early growth is fast. In Zimbabwe trees produce fruits after 4 years. In southern Africa flowering is in (August–)September–December(–April), and fruiting in (November–)January–May(–October). Old fruits remain on the tree until the next flowering season. *Diospyros lycioides* is in leaf year round, with some bare individuals in winter and with new leaves in September–November. The species forms thickets from the root system.

Ecology *Diospyros lycioides* is one of the most widely distributed and ecologically versatile woody species in southern Africa. It occurs from sea-level up to 2700 m altitude and is most common in open vegetation, often along rivers or on termite mounds. It is an indicator of bush encroachment in rangeland in South Africa.

Propagation and planting *Diospyros lycioides* seeds are orthodox and store well. Propagation is best done with seeds soaked overnight in hot water. Propagation by cuttings is very difficult. The 1000-seed weight is 90–140 g. Seedlings require exposure to full sun, but can tolerate very cold conditions. Natural dispersal of seed is mainly by mammals that eat the fruit.

Management In southern Africa *Diospyros lycioides* is collected from natural woodlands. In South Africa it is also planted and tended in home gardens. Plants are spaced at 90–120 cm. Pinching out branch tips when young will encourage a bushy plant. The tree can be coppiced.

In rangeland *Diospyros lycioides* is controlled by slashing followed by application of herbicides to regrowth. In Australia importation of *Diospyros lycioides* is prohibited, except for subsp. *sericea*, which can be imported under strict conditions.

Diseases and pests The species has moderate resistance to termites, borers and fungal attack. It is a food plant of caterpillars of the butterfly *Poecilmitis lycegenes*. Like other species of the genus, *Diospyros lycioides* is probably vulnerable to the sac fungus *Pseudocercospora kaki* which causes leaf spot. The female of the scale insect *Ceroplastes royenae* attacks *Diospyros lycioides* subsp. *sericea* in Zimbabwe.

Harvesting Roots and twigs are generally collected from wild plants. Traditionally, harvesting of medicinal roots for example in Zimbabwe is supposed to be done on one side of the tree. Fruits are picked by hand when fully mature as unripe fruits have a high tannin content. The hard skin easily breaks on impact.

Yield No data on yield of roots or twigs are available.

Handling after harvest Roots to be used as toothbrush are cleaned and they are chewed with the bark on. The fruit coat is fragile and fruits should be handled with care. The fruit may ferment and become sour if stored for several days.

Genetic resources *Diospyros lycioides* is a widespread and hardy species that can become weedy. There are no indications that the species is under threat of genetic erosion.

Prospects *Diospyros lycioides* will remain an important source of chew sticks and traditional medicines. There is need for prospecting of its medicinal potential by pharmaceutical companies, while the indigenous people who have used the plant for long periods of time, should be given due compensation and royalties. At the same time, it has been declared a weed in Australia and an indicator of bush encroachment in South Africa and its control will require monitoring and research. There is a need for further investigation of the taxonomy of the four subspecies.

Major references Cai et al., 2000; Coates Palgrave, 2002; Goldsmith & Carter, 1992; Jansen, 2005; Joffe, 2001; Li, van der Bijl & Wu, 1998; Randal, 2007; van Wyk & van Wyk, 1997; White, 1983; White, 1987.

Other references Aganga et al., 2000; Alves, Cruz Costa & Ferreira, 1973; AQUIS, 2010; Cocks, 2006; Curtis & Mannheimer, 2005; Dehmlow et al., 1998; Duangjai et al., 2009; Fawole et al., 2009; Gelfand et al., 1985; Joffe, 2003; Milton & Dean, 2001; Neuwinger, 2000; SEPASAL, 2010d; Skarpe et al., 2007; Swanepoel, 2006; van Wyk & Gericke, 2000; Venter & Venter, 1996; von Koenen, 2001; Wehmeyer, 1986; Wells et al., 1986.

Sources of illustration de Winter, 1963; White, 1987.

Authors L. Mujuru

DOMBEYA ACERIFOLIA Baker

Protologue J. Linn. Soc., Bot. 22: 449 (1887).

Family Sterculiaceae (APG: Malvaceae)

Origin and geographic distribution *Dombeya acerifolia* is endemic to Madagascar, where it occurs in the eastern and central parts of the country.

Uses Fibre from the bark is made into rope and used for weaving. Fishermen use the rope to thread crabs they caught. The bark is used for tying, and was formerly made into barkcloth. The large, soft leaves are used for washing dishes.

The wood is locally used for purposes where workability is more important than durability. It is used for making rafts and considered suitable for non-visible parts of furniture, interior trim, boxes and other forms of packaging.

Properties The fibre is of good quality, and easy to extract and process. The best fibre is obtained from young, thin bark.

The darker heartwood is normally distinctly demarcated from the paler, cream-coloured sapwood, but in young trees both may have the same white or pink colour. The wood turns reddish on drying. It is lightweight, soft and easy to work, with an average stability in service. The wood is liable to attacks by fungi and insects, and the relatively small size of the logs limits its usability.

Botany Small tree up to 15 m tall, with the branches, petioles, inflorescence axes and pedicels covered with a dense reddish indumentum consisting of short stellate hairs and long hirsute hairs. Leaves alternate, clustered with inflorescences at the end of branches, simple; stipules suborbicular, up to 2 cm × 3 cm, apex rounded or cuspidate, densely hairy, persistent; petiole up to 22.5 cm long, cylindrical, first densely hairy, later glabrescent except for the upper part; blade broadly ovate to suborbicular, unlobed or 3–5-lobed, up to 45 cm × 45 cm, base cordate, apex acute, margin toothed, thick, discolorous, bullate, upper surface dark green and stellate hairy, lower surface greyish or reddish and tomentose, palmately veined with 7 basal veins. Inflorescence an axillary umbel, many-flowered; axis simple or bifurcate, up to 20 cm long, thick. Flowers bisexual, regular, 5-merous; pedicel 2–4 cm long; epicalyx bracts 3, suborbicular, c. 7 mm long, apex rounded or cuspidate, hairy, caducous; calyx deeply 5-fid, lobes lanceolate, 9–10 mm long, apex acuminate, hairy outside, glabrous inside, becoming reflexed; petals free, obliquely obovate, 14–20 mm × 10–14 mm, white to pinkish; androecium utricular, 4–7 mm long, stamens 10–15, filaments unequal, 0.5–5 mm long, free or connate above the utricule, alternating by 2–3 with 5 staminodes 4.5–8 mm long; ovary superior, hairy, 5-celled, stylar column 4.5–8 mm long, with 4–6 branches 2.5–5.5 mm long. Fruit a loculicidal capsule.

Dombeya comprises about 200 species, mainly distributed in Madagascar, with about 20 species in mainland Africa and 14 in the Mascarenes. Revisions of the genus have been carried out for mainland Africa and the Mascarenes, but not for Madagascar, and the number of species described for Madagascar is possibly too high.

Many other *Dombeya* species endemic to Madagascar are used as fibre plants. The bark fibre of *Dombeya albisquama* Arènes, a small to medium-sized tree up to 16 m tall, is used for making rope and weaving cloth. The strong bark was formerly used for tying captives. The wood is used in construction. The bark of *Dombeya alleizettei* Arènes, a small tree up to 8 m tall yields good cordage fibre. The strong fibre from the bark of *Dombeya ambalabeensis* Arènes, a shrub or small to large tree up to 12(–30) m tall is used for making cords to tether cattle.

Ecology *Dombeya acerifolia* occurs up to 1200 m altitude in forest and secondary vegetation. It thrives in humid locations such as along water courses.

Management Formerly the bark was beaten with a mallet to obtain barkcloth, later the fibre was extracted by crushing the bark, after which the fibre was combed or scutched, making it suitable for spinning and weaving. Nowadays, the fibre is usually extracted after retting, and combed. It is locally stored until needed.

Genetic resources and breeding It is unknown whether *Dombeya acerifolia* is threatened by genetic erosion.

Prospects *Dombeya acerifolia* is a useful local source of fibre used for a range of purposes. Detailed information on the fibre properties as well as on the conservation status of the species is lacking, making it difficult to assess the prospects of this species. However, the fact that it is stocked indicates that it is locally highly valued. The small size of the logs limits the prospects of the wood.

Major references Arènes, 1959; Boiteau, Boiteau & Allorge-Boiteau, 1999; Guéneau, Bedel & Thiel, 1970–1975.

Other references Cailliez & Guéneau, 1972; Decary, 1946; Missouri Botanical Garden, undated; Schatz, undated; Seyani, 1991; Vololomboahangy, 2004.

Authors M. Brink

DOMBEYA AMBONGENSIS Arènes

Protologue Candollea 16: 365 (1958).

Family Sterculiaceae (APG: Malvaceae)

Origin and geographic distribution *Dombeya ambongensis* is endemic to Madagascar, where it occurs in the western and southern parts of the country.

Uses The bark yields a good fibre used for making rope and for coarse weaving. Ropes made from this fibre are used for pulling heavy loads. The fibre was formerly used for tying together pieces of frameworks.

Properties The bark fibre is said to be particularly strong. The wood is white and soft, and not much used.

Botany Shrub or small tree up to 10 m tall; branches rounded, bark grey, glabrous, striate, with round, reddish lenticels. Leaves alternate, simple; stipules triangular, up to 0.5 mm long, caducous; petiole 5–12 mm long, cylindrical, glabrous; blade ovate, up to 11 cm × 4 cm, base obtuse, apex long-attenuate, margin wavy, both surfaces glandular, upper surface glabrous or hairy, lower surface glabrous, palmately veined with 5 basal veins, venation prominent, especially below. Inflorescence an axillary umbel, glandular, glabrous, 2–9-flowered. Flowers bisexual, regular, 5-merous; pedicel slender, 12–22 mm long, articulate above the middle; epicalyx bracts 3, ovate, c. 1 mm long, brown, caducous; calyx deeply 5-fid, 8–10 mm long, lobes lanceolate, 3–4 mm long, apex acute, densely glandular outside, glabrous, more or less reflexed; petals free, obovate-elliptical, 5–10 mm × 2–4 mm, white; androecium crown-shaped, stamens 15, staminal tube 0.5–1.5 mm long, filaments free or connate above the crown, unequal, 2–6 mm long, usually alternating by (2–)3(–4) with 5 staminodes 1.5–2.5 mm long, staminodes sometimes absent; ovary semi-inferior, hairy, stylar column 1.5–2 mm long, with 2 branches 0.5–2 mm long. Fruit a loculicidal capsule.

Dombeya comprises about 200 species, mainly distributed in Madagascar, with about 20 species in mainland Africa and 14 in the Mascarenes. Revisions of the genus have been carried out for mainland Africa and the Mascarenes, but not for Madagascar, and the number of species described for Madagascar is possibly too high.

Many other *Dombeya* species endemic to Madagascar are used as fibre plants. The bark fibre of *Dombeya amplifolia* Arènes is made into rope and woven into cloth. The bark of *Dombeya antsianakensis* Baill., a small tree up to 16 m tall, yields a good fibre used for making rope and coarse textiles. The fibre is easy to prepare, especially that of young plants. It is usually extracted after retting and combed. The bark was formerly made into barkcloth. The bark fibre of *Dombeya australis* Scott-Elliot, a shrub or small tree up to 14 m tall, is used by fishermen use for threading and transporting their catch. The wood of this species is used for construction. *Dombeya baronii* Baker, a shrub, yields a good cordage fibre, of which often a prepared stock is kept. The fibre is also used for weaving cloth. Young, thin, flexible barks give the best fibre. The fibrous bark of *Dombeya befotakensis* Arènes, a small tree up to 12 m tall, is used for tying. The bark was formerly made into barkcloth.

Ecology *Dombeya ambongensis* occurs from sea level up to 850 m altitude in dry forest and forest remnants, on sandy and rocky soils.

Management *Dombeya ambongensis* used to be multiplied by cuttings.

Genetic resources and breeding It is unknown whether *Dombeya ambongensis* is threatened by genetic erosion.

Prospects Detailed and quantitative information on the fibre properties is lacking, but *Dombeya ambongensis* seems a useful local source of fibre, as the fibre is recorded to be strong, and the species used to be propagated by man.

Major references Arènes, 1959; Boiteau, Boiteau & Allorge-Boiteau, 1999.

Other references Missouri Botanical Garden, undated; Schatz, undated; Seyani, 1991; Vololomboahangy, 2004.

Authors M. Brink

DOMBEYA BIUMBELLATA Baker

Protologue J. Linn. Soc., Bot. 22: 450 (1887).

Family Sterculiaceae (APG: Malvaceae)

Origin and geographic distribution *Dombeya biumbellata* is endemic to Madagascar.

Uses The bark is used for tying, and the bark fibre for making rope and weaving cloth. Formerly the bark was made into barkcloth. An infusion of the flowers is given to young children who have difficulty to urinate.

Properties The bark fibre is easy to extract and process. Especially young plants with a thin bark are used, because these yield more beautiful fibre than older plants.

The wood is white, turning reddish on drying. It is lightweight, soft and brittle, and without important applications.

Botany Shrub or small tree up to 10 m tall; flowering branches rounded, initially covered with reddish or reddish-brown stellate hairs. Leaves alternate, simple; stipules ovate, up to 13 mm × 1 mm, tomentose; petiole 6–14 cm long, densely stellate hairy; blade very variable, ovate or ovate-suborbicular, unlobed to 3–5-lobed or 3-cuspidate, up to 18 cm × 18 cm, base cordate, apex acuminate or attenuate-acuminate, margin toothed to almost entire, both sides with reddish, reddish brown or rarely greyish stellate hairs. Inflorescence an axillary many-flowered umbel, axis simple or bifurcate, 9–20 cm long, densely stellate hairy. Flowers bisexual, regular, 5-merous; pedicel 0.5–3 cm long; epicalyx bracts 3, ovate to lanceolate-spathulate, 6–7 mm long; calyx deeply 5-fid, hairy outside, glabrous inside, lobes narrowly lanceolate, 5–7 mm long, becoming reflexed or not; petals free, broadly and obliquely obovate, 5–10 mm × 4–10 mm, white or pink; androecium crown-shaped, stamens 15, staminal column 1–2 mm long, filaments unequal, 0.5–3 mm long, free or connate above the crown, alternating with 5 staminodes 4–7 mm long; ovary superior, hairy, stylar column 2–6 mm long, with 4–5 branches 2–3.5 mm long. Fruit a loculicidal capsule.

Dombeya comprises about 200 species, mainly distributed in Madagascar, with about 20 species in mainland Africa and 14 in the Mascarenes. Revisions of the genus have been carried out for mainland Africa and the Mascarenes, but not for Madagascar, and the number of species described for Madagascar is possibly too high.

Many other *Dombeya* species endemic to Madagascar are used as fibre plants. The bark of *Dombeya boeniensis* Arènes, a small tree up to 12 m tall with a bole up to 20 cm in diameter, yields good fibre for rope-making. The bark fibre of *Dombeya breonii* Baill., a small tree up to 7 m tall, is used for cordage and textiles. It is usually extracted after retting and combed.

Ecology *Dombeya biumbellata* thrives in humid locations. It occurs at altitudes up to 1400 m.

Management *Dombeya biumbellata* is frequently planted near villages. The fibre is easy to extract and process. Formerly the bark was beaten with a mallet to obtain barkcloth, later the fibre was extracted by crushing the bark, after which the fibre was combed or scutched, making it suitable for spinning and weaving. Nowadays, the bark is retted to obtain the fibre. The fibre is stored to have it at hand when needed.

Genetic resources and breeding *Dombeya biumbellata* is common around villages, where it is planted, and seems not threatened by genetic erosion.

Prospects *Dombeya biumbellata* is a useful local source of material for tying and rope making. As detailed information on the fibre properties is lacking, it is difficult to assess the prospects of this species. It is, however, frequently planted and the fibre is kept in stock, indicating that it is highly valued.

Major references Arènes, 1959; Boiteau, Boiteau & Allorge-Boiteau, 1999.

Other references Missouri Botanical Garden, undated; Schatz, undated; Seyani, 1991; Vololomboahangy, 2004.

Authors M. Brink

DOMBEYA BUETTNERI K.Schum.

Protologue Bot. Jahrb. Syst. 15: 133 (1892).

Family Sterculiaceae (APG: Malvaceae)

Chromosome number $2n = 54$.

Synonyms *Dombeya bagshawei* Baker f. (1905), *Dombeya claessensii* De Wild. (1928).

Origin and geographic distribution *Dombeya buettneri* is distributed from Guinea and Sierra Leone eastward through the coastal countries of West Africa, the Central African Republic and northern DR Congo to Sudan and eastern Ethiopia, and from there southward through eastern DR Congo, Rwanda, Burundi, Uganda and Tanzania to Zambia.

Uses The stem bark is locally used for tying and for making ropes and nets. In DR Congo it is made into cords that are used to support a basket on the back for carrying. In Uganda the bark is used for making baskets and the young shoot for making beehives.

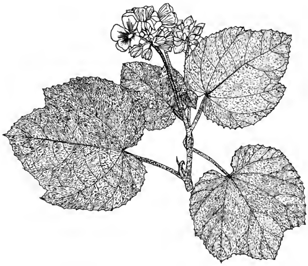
In African traditional medicine an infusion of the root is drunk as a laxative and a decoction of the root is drunk to prevent miscarriage. Root, bark and leaf preparations are used against diarrhoea. An aqueous extract of the leaf is used for the treatment of gastrointestinal problems. The leaf sap is applied on wounds, and the powdered leaf or a decoction of the leaf is taken or inhaled against headache. A decoction of the leaf is drunk to prevent diseases in children and as an emetic, whereas an infusion of the leaf is used for the treatment of haemorrhoids. A decoction of the leaf or leafy twig forms part of preparations drunk for the treatment of mental illness.

In traditional veterinary medicine the leaf sap forms part of preparations given to cattle with diarrhoea or theileriosis (East Coast fever).

Properties Investigations in Rwanda in the 1950s indicated that the fibre had a specific strength of 427 N/mm^2 and a breaking length of 29 km.

In experiments with rats, an aqueous extract of the leaf caused significant reduction in gastric acid secretion and reduced the extent of gastric mucosal damage induced by ethanol.

Botany Shrub or small tree up to 10 m tall; outer bark brown; inner bark tough and fibrous, exuding a sticky sap when cut; stems terete or angled at nodes, densely covered with stellate, simple, glandular hairs or glabrescent. Leaves alternate, simple; stipules narrowly lanceolate to broadly ovate, 6–20 mm × 2–11 mm, acuminate, more or less persistent; petiole (1.5–)2–19(–23) cm long, hairy; blade suborbicular, obscurely to distinctly 3–5-lobed, 5–26 cm × 3.5–25 cm, base cordate, apex acute to rounded or emarginate, margin toothed, upper surface softly pubescent or puberulous, lower surface densely pilose-pubescent or tomentose. Inflorescence axillary, corymbose, rarely subumbellate, 4–23(–27) cm long, dense or lax, many-flowered; peduncle 2–22 cm long, hairy; bracts ovate-lanceolate, 6–12 mm × 2–6 mm, acuminate, caducous. Flowers bisexual, regular, 5-merous; pedicel 7–40 mm long; epicalyx bracts at base of calyx or inserted on pedicel, ovate, 6–16 mm × 2–7 mm, acute to acuminate, caducous; calyx lobes reflexed or erect, lanceolate-acuminate, 6–15 mm × 2–5(–6) mm, hairy outside; petals obliquely obovate, 9–20 mm × 6–16 mm, white to pale pink, sometimes with a red base, androecium 9–16 mm long, stamens 10–15, in a single whorl, up to 6 mm long, alternating with 5 staminodes 5–11 mm long, all filaments united into a staminal tube 1–7 mm long with a strongly convex outer surface; ovary superior, globose, hairy, 5-celled, style 4–9 mm long, 5-branched. Fruit an ovoid to globose capsule 7–9 mm in diameter, brown, appressed silky-hairy. Seeds trigonous, 2–3 mm × 1–3 mm, rough, reddish or dark brown.



Dombeya buettneri – flowering twig.
Source: Flore analytique du Bénin

In Benin *Dombeya buettneri* flowers and bears fruits in November–January.

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Ecology *Dombeya buettneri* occurs from 150 m altitude in West Africa up to 2200 m altitude in East Africa, in grassland, bushland, wooded grassland, open woodland and forest. It is also found in abandoned fields.

Management *Dombeya buettneri* can be propagated by seed and wildlings. Seed should be collected before the fruit splits open. The tree coppices well. Regrowth is abundant after cutting or after bush fires, and thinning and pruning are recommended. In Rwanda the bark is removed from the stem and retted in running water for 3–4(–15) days, after which it is scraped to obtain the fibre. About 1 kg of fibre was obtained from 34 kg of green, defoliated stems.

Genetic resources and breeding As *Dombeya buettneri* is widespread and common, it is not threatened with genetic erosion.

Prospects *Dombeya buettneri* is locally used as fibre plant. Detailed information on its properties is lacking. *Dombeya buettneri* has various uses in traditional medicine, and the usefulness of the leaf in the treatment of gastrointestinal problems has been confirmed in experiments with rats.

Major references Burkill, 2000; Cheek & Dorr, 2007; Katende, Birnie & Tengnäs, 1995; Seyani, 1991; Vollesen, 1995b.

Other references Adjanohoun et al., 1989; Akoègninou, van der Burg & van der Maesen, 2006; Baerts & Lehmann, 1989; Bizimana, 1994; Dubois, 1951; Irvine, 1961; Lejeune, 1953; Neuwinger, 2000; Okwari et al., 2000; Terashima & Ichikawa, 2003.

Sources of illustration Akoègninou, van der Burg & van der Maesen, 2006.

Authors M. Brink

DOMBEYA BURGESSIAE Gerrard ex Harv.

Protologue Fl. Cap. 2: 590 (1862).
Family Sterculiaceae (APG: Malvaceae)
Chromosome number $2n = 54$

Synonyms *Dombeya mastersii* Hook.f. (1867), *Dombeya platypoda* K.Schum. (1900), *Dombeya dawei* Sprague (1906).

Vernacular names Pink dombeya, pink wild pear (En).

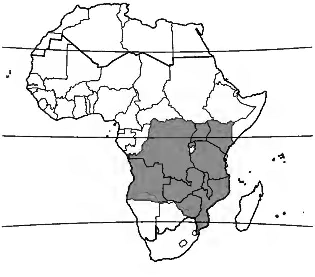
Origin and geographic distribution *Dombeya burgessiae* is distributed from DR Congo, Uganda and Kenya south to Angola, Zambia, Zimbabwe and Mozambique and also occurs in South Africa and Swaziland.

Uses The bark fibre of *Dombeya burgessiae* is widely used for binding and for making rope. In Kenya the fibre is traditionally used for making baskets and the famous 'kiondo' bags.

In Kenya the wood is used for construction and for making bows. In Mozambique the wood is used for bows, tool handles and for firewood. The wood is widely used to light a fire by friction. In Malawi and Mozambique the pith is boiled and eaten as a side dish. Like other species of the genus, *Dombeya burgessiae* is valuable as bee forage and the honey produced is exceptionally good with fine crystallization. *Dombeya burgessiae* is cultivated as an ornamental in southern Africa.

In traditional medicine in Kenya the bark is boiled and the decoction drunk or the bark is chewed as an aphrodisiac. An infusion of the roots is taken to cure stomach pain. In Tanzania a decoction of the leaves is drunk and pulped leaves are applied to leprosy sores.

Properties The heartwood is not clearly demarcated from the sapwood. The wood is uniformly pale brown, often with a central core of dark brown wood with olive streaks. The grain is usually straight, texture fine to medium. The density of the wood is about 560 kg/m^3 at 12% moisture content. The wood is liable to checking in seasoning. It is strong and tough. At 12% moisture content, the modulus of rupture is about 96 N/mm^2, modulus of elasticity 12,500 N/mm^2, compression parallel to grain 48 N/mm^2, shear 11.6 N/mm^2, cleavage 46 N/mm radial and 66 N/mm tangential, Janka side hardness 4140 N and Janka end hardness 5420 N.



Dombeya burgessiae – wild

The wood saws and planes well and nails without splitting, but it is not suitable for turnery. The durability of the wood is low to moderate. The sapwood is susceptible to attack by termites, marine borers and *Lyctus* borers. The sapwood and heartwood are moderately resistant to impregnation.

The leaves contain polyuronoids and steroids, and bufadienolides are probably also present in the leaf material. Water and methanol extracts of the leaves have no or negligible anti-bacterial activity. Ethanol and dichloromethane extracts of the leaves showed a high level of cyclooxygenase-1 (COX-1) inhibition, indicating anti-inflammatory activity. The treatment of wounds and stomach-ache may be attributable to these properties.

Botany Shrub 2–4(–8) m tall; outer bark brown, inner bark tough and fibrous; branches densely hairy or glabrescent, with simple and stellate needle-shaped hairs, and subsessile and stalked glandular hairs. Leaves alternate, simple; stipules lanceolate to broadly ovate, 8–13 mm × 3–6 mm, long-acuminate; petiole 7–15 cm long; blade suborbicular, distinctly 3-lobed, rarely 5-lobed or entire, 11–23 cm × 7–18 cm, base deeply cordate, apex acuminate, margin irregularly toothed, upper surface sparsely to densely pubescent, tomentose or tomentellous, lower surface usually densely pubescent, tomentose or tomentellous, with mostly long-armed hairs. Inflorescence axillary, corymbose or subumbellate, 6–21 cm × 3–6 mm, many-flowered; peduncle 4–17 cm long, sparsely or densely hairy; bracts ovate, c. 11 mm long, acuminate, caducous. Flowers bisexual, regular, 5-merous; pedicel 22–40 mm long; epicalyx bracts at base of calyx, rarely on pedicel, elliptical, ovate, oblong, lanceolate or oblanceolate, 10–14 mm × 2–5 mm, acute to long-acuminate, caducous; calyx lobes reflexed, lanceolate, 9–13 mm × 2–8 mm, hairy outside; petals spreading, obliquely obovate, 12–25 mm × 10–25 mm, white or pink, base and veins sometimes red; stamens (10–)15, in groups of 3, alternating with staminodes 7–16 mm long, all filaments united into a staminal tube 1–5 mm long; ovary superior, globose, hairy, 5-celled, style 5–16 mm long, 5-branched. Fruit an ovoid to globose capsule 5–15 mm in diameter, brown, hairy. Seeds trigonous, 3–4 mm × 2 mm, rough, dark brown to black.

Dombeya burgessiae exhibits a lot of variation and was consequently described repeatedly under different names. In southern Africa *Dombeya burgessiae* flowers in April–July and fruits ripen in June–October.

Dombeya comprises about 200 species, mainly distributed in Madagascar, with about 20 species in mainland Africa and 14 in the Mascarenes. Revisions of the genus have been carried out for mainland Africa and the Mascarenes, but not for Madagascar, and the number of species described for Madagascar is possibly too high.

Ecology *Dombeya burgessiae* belongs to the Afromontane flora and is found up to 2400 m altitude. In East Africa the lower altitude limit is c. 900 m, but in Mozambique and South Africa it can be found at sea-level. It is most common in the early stages of forest regrowth, in dry open forest, at forest margins, along rivers and in woodland.

Management Seed can be extracted from dry flower heads. Its viability declines within 3 months, so fresh seed has to be used for sowing. Seed is to be sown in properly drained seedbeds. Seedlings emerge in about 3 weeks. For the ornamental trade, plants are multiplied by cuttings or air-layers.

Genetic resources and breeding As *Dombeya burgessiae* is very widespread and common, it seems not threatened with genetic erosion. Germplasm of several species with ornamental value is available at various research institutes in the subtropics. Self-incompatibility is common in the genus and explains the wide variation in several species. It opens opportunities for selection and breeding. The first ornamental *Dombeya* hybrid is *Dombeya ×cayeuxii* André, produced in 1895 in Portugal as a result of crossing *Dombeya burgessiae* and *Dombeya wallichii* (Lindl.) K.Schum. from Madagascar. A number of named cultivars, selections from *Dombeya burgessiae* and hybrids with *Dombeya burgessiae* as one of the parents, have been developed in Florida (United States) and are planted as ornamentals elsewhere as well. The cultivar 'Seminole' has some promise as an indoor pot plant.

Prospects As a fibre producer, *Dombeya burgessiae* will only remain important for local use. It contains bufadienolides which are of interest as potential anti-cancer agents. It is probable that the horticultural industry in the subtropics will continue to release new cultivars.

Major references Cheek & Dorr, 2007; Latham, 2007; Seyani, 1991; Takahashi, 1978.

Other references Bolza & Keating, 1972; Coates Palgrave, 1983; Neuwinger, 2000; Reid et al., 2005; Soderholm, 1973; Staples & Herbst, 2005; Stefanesco & Bintoni-Juliassi, 1982; van Wyk & van Wyk, 1997; Williamson, 1955.

Authors C.H. Bosch

DOMBEYA CACUMINUM Hochr.

Protologue Candollea 3: 102 (1926).

Family Sterculiaceae (APG: Malvaceae)

Vernacular names Strawberry snowball tree (En).

Origin and geographic distribution *Dombeya cacuminum* is endemic to Madagascar. It is cultivated outside Madagascar as an ornamental, for instance in South Africa and the United States.

Uses The bark yields a good cordage fibre, which is also used for weaving cloth. The bark was formerly made into barkcloth. *Dombeya cacuminum* is grown as an ornamental outside Madagascar.

Properties This evergreen tree has ornamental value, because of its beautiful flowers which fall before withering. The leaf is recorded to have a nauseous odour.

Botany Small to medium-sized tree up to 16 m tall; bole up to 30 cm in diameter; bark of flowering branches brown and glabrous. Leaves alternate, simple; stipules broadly ovate or suborbicular, c. 15 mm long, almost glabrous, caducous; petiole up to 25 cm long, cylindrical, glabrous except for the top; blade suborbicular to 3-lobate, up to 26 cm × 22 cm, base deeply cordate, lobes triangular, the central one the largest, apex of lobes long-acuminate, margin toothed, both surfaces glabrous except for the basal veins, palmately veined with 9–11 basal veins, venation prominent, especially below. Inflorescence an axillary umbellate cyme, grouped at the tops of branches, up to 15 cm long; axis irregularly bifurcated, glabrous, branches glabrous. Flowers bisexual, regular, 5-merous; pedicel 3–4.5 cm long, glabrous; epicalyx bracts 3, suborbicular, c. 1 cm long, glabrous, caducous; calyx deeply 5-fid, c. 2 cm long, hairy outside, lobes lanceolate, ultimately reflexed; petals free, broadly and asymmetrically obovate, up to 45 mm × 35 mm, red to purple; androecium crown-shaped, staminal crown 1–1.5 mm long, stamens 15, filaments unequal, 4.5–10 mm long, free or connate above the crown, alternating with 5 staminodes 20–23 mm long; ovary superior, hairy, stylar column 30–35 mm long, with 5 branches. Fruit an ovoid capsule c. 13 mm long, hairy, loculicidal. Seeds obovoid-trigonous, c. 2.5 mm long, brown.

Dombeya comprises about 200 species, mainly distributed in Madagascar, with about 20 species in mainland Africa and 14 in the Mascarenes. Revisions of the genus have been carried out for mainland Africa and the Mascarenes, but not for Madagascar, and the number of species described for Madagascar is possibly too high.

Species endemic to Madagascar of which the bark fibre is used for similar purposes as that of *Dombeya cacuminum* include *Dombeya condensata* Hochr., a small tree up to 12 m tall, and *Dombeya costulatinervia* Arènes, a small tree up to 15 m tall. The bark fibre of *Dombeya dichotomopsis* Hochr., a shrub or small tree up to 11 m tall is also used for making rope. In the past the strong bark was used for tying captives. A decoction of the leaf is used against cough.

Ecology *Dombeya cacuminum* occurs in forest up to 2000 m altitude. It is locally common. The plant tolerates temperatures down to –2°C.

Management Formerly the bark was beaten with a mallet to obtain barkcloth, later the fibre was extracted by crushing the bark, after which the fibre was combed or scutched, making it suitable for spinning and weaving.

Genetic resources and breeding It is unknown whether *Dombeya cacuminum* is threatened by genetic erosion.

Prospects *Dombeya cacuminum* is a useful local source of fibre for cordage and weaving, but quantitative information on the fibre properties is lacking. On a worldwide scale the prospects as an ornamental plant are better.

Major references Arènes, 1959; Boiteau, Boiteau & Allorge-Boiteau, 1999; Vololomboahangy, 2004.

Other references Carrière et al., 2005; Decary, 1946; Missouri Botanical Garden, undated; Schatz, undated; Seyani, 1991.

Authors M. Brink

DOMBEYA CORIA Baill.

Protologue Bull. Mens. Soc. Linn. Paris 1: 491 (1885).

Family Sterculiaceae (APG: Malvaceae)

Origin and geographic distribution *Dombeya coria* is endemic to Madagascar, where it occurs in the eastern part of the country.

Uses The bark yields excellent fibre for rope making. The fibre was traditionally used by fishermen to make fishing lines and to string caught crabs. It was also used for attaching pieces of wood before nails were used for this purpose. The bark was formerly made into barkcloth.

Botany Shrub or small tree up to 15 m tall; branches cylindrical, with a brown and glabrous bark. Leaves alternate, simple; stipules ovate to orbicular, 10–20 mm × 7–15 mm, with acumen 3–10 mm long, hairy, caducous; petiole up to 15 cm long, cylindrical, lower part glabrous, upper part with stellate and simple hairs; blade broadly ovate with an acuminate apex, or orbicular with 3 triangular, acuminate lobes, up to 19 cm × 19 cm, base deeply cordate, apex acuminate or rounded, margin toothed and ciliate, both surfaces stellate hairy, upper surface shiny, lower surface paler, palmately veined with 5–7 basal veins, venation prominent, especially below. Inflorescence an axillary umbel, axis up to 18 cm long, lower part glabrous, upper part laxly hairy, many-flowered. Flowers bisexual, regular, 5-merous; pedicel up to 6 cm long; epicalyx bracts 3, inserted on pedicel, ovate-orbicular, 15 mm × 10 mm, with acumen 5 mm long, caducous; calyx deeply 5-fid, lobes lanceolate, up to 25 mm long, apex acuminate, hairy outside; petals free, obovate, asymmetrical, 30 mm × 22 mm, pink; androecium utricle-shaped, utricle 2.5 mm long, stamens 25–30, white, filaments 5 mm long, alternating with 5 staminodes 12 mm long; ovary superior, hairy, 5-celled, stylar column 13–15 mm long, with 5 branches 3–3.5 mm long. Fruit a loculicidal capsule.

Dombeya comprises about 200 species, mainly distributed in Madagascar, with about 20 species in mainland Africa and 14 in the Mascarenes. Revisions of the genus have been carried out for mainland Africa and the Mascarenes, but not for Madagascar, and the number of species described for Madagascar is possibly too high.

Various other *Dombeya* species endemic to Madagascar yield excellent cordage fibre, such as *Dombeya andapensis* Arènes, a small tree up to 13 m tall, *Dombeya cannabina* (Bojer) Baill., a small tree up to 10 m tall, not only used for cordage but also for making clothes, *Dombeya macropoda* Hochr., a shrub or small tree up to 12 m tall, not only valued for its fibre but also for its wood, which is white and easy to carve and was formerly sought after for making dug-out canoes, and *Dombeya somanga* Arènes, a small tree often planted near dwellings to have material for tying at hand.

Ecology *Dombeya coria* occurs up to 1200 m altitude, in forest and along streams.

Management Formerly the bark was beaten with a mallet to obtain barkcloth, later the fibre was extracted by crushing the bark, after which the fibre was combed or scutched, making it suitable for spinning and weaving. Nowadays, the bark is retted to obtain the fibre. The fibre is stored to have it at hand when needed.

Genetic resources and breeding It is unknown whether *Dombeya coria* is threatened by genetic erosion.

Prospects Quantitative information on the fibre properties is lacking, but the fibre of *Dombeya coria* has a very good reputation. The fact that is kept in stock to have it at hand when needed also indicates that it is locally highly valued.

Major references Arènes, 1959; Boiteau, Boiteau & Allorge-Boiteau, 1999.

Other references Decary, 1946; Missouri Botanical Garden, undated; Schatz, undated; Seyani, 1991.

Authors M. Brink

DOMBEYA ELLIPTICA Bojer

Protologue Rapp. Annuel Trav. Soc. Hist. Nat. Ile Maurice 12: 46 (1841).

Family Sterculiaceae (APG: Malvaceae)

Origin and geographic distribution *Dombeya elliptica* is endemic to Madagascar. It has been grown in the 'Jardin des Pamplemousses' in Mauritius.

Uses Fibre from the bark is used for making rope. Properly prepared, it can be woven in the same way as jute. The bark was formerly made into barkcloth. The fruits are eaten.

Properties The bark fibre is recorded to be of good quality. The wood is white, soft and brittle.

Botany Shrub or small to medium-sized tree up to 25 m tall, almost entirely covered with 2 types of stellate hairs, one reddish and dense, the other brown, longer and less dense; bole up to 25 cm in diameter; young branches hairy, older ones glabrous or glabrescent, striate, glandular. Leaves alternate, simple; stipules ovate-oblong, c. 3 mm long, caducous; petiole 0.5–3 cm long, cylindrical, densely hairy; blade very variable, ovate, elliptical or obovate-elliptical, up to 11.5 cm × 7 cm, base rounded or slightly cordate, apex rounded or attenuate-acute, margin toothed irregularly, leathery, upper surface green and laxly hairy, lower surface tawny or brown and velvety, palmately veined with 5–7 basal veins, prominent below. Inflorescence an axillary, solitary cyme, corymbiform or paniculate, 3–16 cm long, hairy, many-flowered. Flowers bisexual, regular, 5-merous; pedicel c. 5 mm long; epicalyx bracts 3, inserted on pedicel, linear-oblong, c. 1.5 mm long, caducous; calyx deeply 5-fid, lobes ovate-lanceolate, 2.5–3 mm long, hairy outside, not reflexed; petals free, broadly obovate, 4.5 mm × 3 mm, white; androecium crown-shaped, staminal crown c. 1 mm long, stamens 10–15, filaments unequal, 5 mm long, connate above the crown, alternating by 2–3 with 5 spoon-shaped staminodes 2.5 mm long; ovary superior, hairy, stylar column 2 mm long, with 2–4 lobes c. 1 mm long. Fruit a loculicidal capsule.

Dombeya comprises about 200 species, mainly distributed in Madagascar, with about 20 species in mainland Africa and 14 in the Mascarenes. Revisions of the genus have been carried out for mainland Africa and the Mascarenes, but not for Madagascar, and the number of species described for Madagascar is possibly too high.

Other *Dombeya* species endemic to Madagascar of which the bark fibre is used for similar purposes as that of *Dombeya elliptica* include *Dombeya farafanganica* Arènes, a shrub or small tree up to 12 m tall, *Dombeya heimii* Arènes and *Dombeya ianthotricha* Arènes.

Ecology *Dombeya elliptica* occurs from sea level up to 1600 m altitude, in forest, on denudated hills, along streams and rivers, and along roads. It is often found in rocky locations.

Management *Dombeya elliptica* is often planted and protected around houses and on field boundaries, to have its fibrous bark at hand. Formerly the bark was beaten with a mallet to obtain barkcloth, later the fibre was extracted by crushing the bark, after which the fibre was combed or scutched, making it suitable for spinning and weaving.

Genetic resources and breeding It is unknown whether *Dombeya elliptica* is threatened by genetic erosion.

Prospects Detailed and quantitative information on the fibre properties is lacking, but *Dombeya elliptica* seems a useful local source of cordage, as the fibre has a good reputation, and the species is often planted and protected.

Major references Arènes, 1959; Boiteau, Boiteau & Allorge-Boiteau, 1999.

Other references Decary, 1946; Friedmann, 1987; Missouri Botanical Garden, undated; Moggi, 1994; Schatz, undated; Seyani, 1991.

Authors M. Brink

DOMBEYA HILSENBERGII Baill.

Protologue Bull. Mens. Soc. Linn. Paris 1: 495 (1885).

Family Sterculiaceae (APG: Malvaceae)

Origin and geographic distribution *Dombeya hilsenbergii* occurs in Madagascar and the Comoros.

Uses Fibre from the bark is used for making rope. Properly prepared, it can be woven in the same way as jute. Formerly the bark was made into barkcloth, and the fibres were used in circumcision ceremonies. The large, soft leaves are used for washing dishes.

Properties The fibre is of good quality. The wood is white, soft and brittle.

Botany Tree up to 20 m tall; bole up to 30 cm in diameter; branches rounded, bark greyish brown with paler lenticels. Leaves alternate, simple; stipules ovate-lanceolate, up to 1.5 cm long, early caducous; petiole 5–20 cm long, rounded, glabrous; blade broadly ovate, 10–30 cm × 8–20 cm, base deeply cordate, apex long-acuminate, margin toothed, both sides glabrous or glabrescent, palmately veined with 7–9 basal veins, venation strongly prominent, especially below. Inflorescence an axillary corymb, pendant, dense, many-flowered; peduncle 10–25 cm long; bracts 1–2, early caducous. Flowers bisexual, regular, 5-merous, fragrant; epicalyx bracts 3; calyx deeply 5-fid, 8–10 mm long, lobes lanceolate, 6–7 mm long, apex acute, reddish hairy outside, more or less reflexed; petals free, elliptical, 8–12 mm × 4–5 mm, white to cream; androecium tubular, staminal tube 17–21 mm long, white, carrying 10–12 stamens and 5 staminodes, anthers almost sessile, red, alternating by 2–3 with staminodes 2–3 mm long; ovary superior, hairy, 5-celled, stylar column 3 cm long, 5-lobed. Fruit a loculicidal capsule.

Dombeya hilsenbergii is often self-propagating around houses.

Dombeya comprises about 200 species, mainly distributed in Madagascar, with about 20 species in mainland Africa and 14 in the Mascarenes. Revisions of the genus have been carried out for mainland Africa and the Mascarenes, but not for Madagascar, and the number of species described for Madagascar is possibly too high.

Other *Dombeya* species endemic to Madagascar of which the bark fibre is used for making rope include *Dombeya glabripes* Arènes, *Dombeya hafodahy* Arènes, *Dombeya hafodahyformis* Arènes and *Dombeya halapo* Arènes. The leaves of *Dombeya hafodahy* are used as toilet paper.

Ecology *Dombeya hilsenbergii* occurs at 600–1100 m altitude, in forest, secondary vegetation and along rivers.

Management *Dombeya hilsenbergii* is often planted near dwellings to have tying material at hand. Formerly the bark was beaten with a mallet to obtain barkcloth, later the fibre was extracted by crushing the bark, after which the fibre was combed or scutched, making it suitable for spinning and weaving.

Genetic resources and breeding It is unknown whether *Dombeya hilsenbergii* is threatened by genetic erosion.

Prospects Although quantitative information on the fibre properties is lacking, *Dombeya hilsenbergii* seems a very useful local source of cordage fibre, as the fibre is recorded to be of good quality, and the species is often planted.

Major references Arènes, 1959; Boiteau, Boiteau & Allorge-Boiteau, 1999.

Other references Brown et al., 2009; Missouri Botanical Garden, undated; Schatz, undated; Seyani, 1991.

Authors M. Brink

DOMBEYA LAURIFOLIA (Bojer) Baill.

Protologue Bull. Mens. Soc. Linn. Paris 1: 494 (1885).

Family Sterculiaceae (APG: Malvaceae)

Origin and geographic distribution *Dombeya laurifolia* is endemic to Madagascar, where it occurs in the eastern part of the country.

Uses Fibre from the bark is used for making rope. Properly prepared fibres can be woven in the same way as jute and be used for the production of sacks. The bark is used for bundling rice and other agricultural products. In the past it was used for tying captives and made into barkcloth. The wood is used for construction and planks; it is suitable for the production of boxes and crates.

Properties Reports on the fibre quality range from inferior to excellent for rope making. The wood is white, soft and brittle.

Botany Shrub or small tree up to 15(–18) m tall, with branches densely covered with brown scales; bark of older branches reddish or brown, furrowed, mucilaginous; young branches angular. Leaves alternate, simple, entire; stipules triangular, 2–2.5 mm long, caducous; petiole 3–15 mm long, angular, densely scaly; blade very variable, obovate, elliptical or rarely lanceolate, 2.5–13 cm × 1–5.5 cm, base cuneate, attenuate or rounded, apex acuminate, rounded, retuse or attenuate, margin entire and more or less revolute, leathery, both surfaces scaly, but lower surface more densely so, upper surface becoming glabrous and shiny, palmately veined with 3 basal veins. Inflorescence an axillary cyme 2–7 cm long, densely scaly. Flowers bisexual, regular, 5-merous; pedicel 3–10 cm long, angular, scaly; epicalyx bracts 3, inserted on pedicel, ovate, 1–1.5 mm long, caducous; calyx deeply 5-fid, lobes ovate-lanceolate, 3–4 mm long, scaly outside, glabrous inside; petals free, broadly and obliquely obovate, 6–10 mm × 3–7 mm, white; androecium crown-shaped, staminal tube 0.5–1.5 mm long, stamens 5–10(–15), filaments unequal, 0.5–2.5 mm long, free or connate above the crown, alternating by 1–2(–3) with 5 staminodes 3–4.5 mm long; ovary superior, globose, densely scaly, 2–4(–5) locular; stylar column 0.5–1 mm long, with 2–4(–5) branches 1–3.5 mm long. Fruit a loculicidal capsule.

Dombeya comprises about 200 species, mainly distributed in Madagascar, with about 20 species in mainland Africa and 14 in the Mascarenes. Revisions of the genus have been carried out for mainland Africa and the Mascarenes, but not for Madagascar, and the number of species described for Madagascar is possibly too high.

Many other *Dombeya* species endemic to Madagascar are used as fibre plants. The bark fibre of *Dombeya longicuspis* Baill., a shrub up to 5 m tall, is used for making rope. The branches of *Dombeya mandenensis* Arènes, a shrub or small tree up to 8 m tall, are excellent toothbrushes; they contain a mucilage helping against inflammation of the gums. The wood is used as fuelwood. Care should be taken in the exploitation of this species, however, as it is threatened with extinction. Fibre from the bark of *Dombeya mandrakensis* Arènes is used for making rope.

Ecology *Dombeya laurifolia* occurs up to 1300(–1400) m altitude in forest, sometimes in rocky locations.

Management *Dombeya laurifolia* is often planted around villages. The bark is often bored by phytophagous insects. Formerly the bark was beaten with a mallet to obtain barkcloth, later the fibre was extracted by crushing the bark, after which the fibre was combed or scutched, making it suitable for spinning and weaving.

Genetic resources and breeding *Dombeya laurifolia* is widespread and common around villages, and therefore it seems not threatened with genetic erosion.

Prospects *Dombeya laurifolia* is a useful local source of material for tying and rope making. As detailed information on the fibre properties is lacking, it is difficult to assess the prospects of this species.

Major references Applequist, 2009; Arènes, 1959; Boiteau, Boiteau & Allorge-Boiteau, 1999.

Other references Carter Ingram, Whittaker & Dawson, 2005; Dumetz, 1999; Lowry, Randriatafika & Rabenantoandro, 2008; Missouri Botanical Garden, undated; Schatz, undated; Seyani, 1991.

Authors M. Brink

DOMBEYA LUCIDA Baill.

Protologue Bull. Mens. Soc. Linn. Paris 1: 496 (1885).

Family Sterculiaceae (APG: Malvaceae)

Origin and geographic distribution *Dombeya lucida* is endemic to Madagascar, where it occurs in the northern, central, eastern and southern parts of the country.

Uses The bark fibre is used for cordage and weaving. The bark is used for tying; it formerly served for tying captives. Fibrous material is also used for wickerwork.

The wood is locally used for construction and for purposes where workability is more important than durability. It is considered suitable for non-visible parts of furniture, interior trim, boxes and other forms of packaging, but the relative small size of the logs is limiting its usability. The wood is also used as fuelwood. The tree has ornamental value for its flowers.

Properties Reports on the fibre quality are inconsistent, ranging from inferior to good.

The dark heartwood is normally distinctly demarcated from the paler, cream-coloured sapwood, but in young trees both may have the same white or pink colour. The wood is lightweight, soft and easy to work, with an average stability in service. It is very liable to attacks by fungi, termites and other insects.

Botany Shrub or small to medium-sized tree up to 20 m tall; bole up to 40 cm in diameter; young branches angular, older branches rounded, reddish brown or blackish, covered with a dense, scaly indumentum. Leaves alternate, simple; stipules ovate, up to 8 mm long, attenuate-acuminate, caducous; petiole 1–14 cm long, angular, scaly; blade very variable in shape and size, ovate, obovate, oblong, elliptical or suborbicular, up to 20 cm × 20 cm, apex rounded or acuminate, base rounded or cordate, margin entire or wavy, coriaceous, lower surface densely scaly, upper surface first scaly, later glabrous, palmately veined with 3–7 basal veins, strongly prominent below. Inflorescence an axillary, solitary cyme 8–20 cm long, often branched from the base, scaly, rust-coloured. Flowers bisexual, regular, 5-merous; pedicel 2–5 mm long; epicalyx bracts 3, inserted on pedicel, early caducous; calyx deeply 5-fid, lobes ovate, ovate-lanceolate or oblong-lanceolate, 3–6 mm long, scaly outside, glabrous inside, not reflexed; petals free, asymmetrical, broadly obovate or obovate-globose, 5–12 mm × 2–12 mm, white to cream; androecium crown-shaped, stamens 5–15, staminal tube 0.5–2 mm long, filaments free or connate above the crown, unequal, up to 3 mm long, alternating by 1–3 with 5 staminodes 2.5–6.5 mm long; ovary superior, densely scaly for at least the upper part, 5-celled, stylar column 1–4 mm long, with 2–4 branches 1–4 mm long. Fruit a loculicidal capsule.

Dombeya comprises about 200 species, mainly distributed in Madagascar, with about 20 species in mainland Africa and 14 in the Mascarenes. Revisions of the genus have been carried out for mainland Africa and the Mascarenes, but not for Madagascar, and the number of species described for Madagascar is possibly too high.

Several *Dombeya* species endemic to Madagascar yield bark fibres of inferior quality, only used for coarse, not very strong cordage, such as *Dombeya bemarivensis* (Hochr.) Arènes, a small to medium-sized tree up to 22 m tall, *Dombeya borraginea* Hochr., a shrub or small tree up to 9 m tall, *Dombeya leucomacrantha* Hochr., a shrub or small tree up to 6 m tall, *Dombeya oblongifolia* Arènes, a shrub or small to medium-sized tree up to 15 m tall and *Dombeya subsquamosa* Hochr., a shrub or tree.

Ecology *Dombeya lucida* occurs from sea level up to 2300 m altitude in forest, along rivers and in swamps. It is locally common.

Management The fibre is usually extracted after retting, and combed.

Genetic resources and breeding *Dombeya lucida* is widely distributed within Madagascar and is locally common. Therefore it is unlikely to be threatened by genetic erosion.

Prospects *Dombeya lucida* is a useful local source of fibre, but reports on the quality of the fibre are inconsistent, and detailed and quantitative information on the fibre properties is lacking. Therefore the prospects of *Dombeya lucida* as a fibre plant are unclear. Its prospects as a source of timber are limited because the wood is not durable and the logs are often small.

Major references Arènes, 1959; Boiteau, Boiteau & Allorge-Boiteau, 1999; Guéneau, Bedel & Thiel, 1970–1975.

Other references Cailliez & Guéneau, 1972; Huttel, Touber & Clüsener-Godt, 2002; Missouri Botanical Garden, undated; Razafimahatratra, 1996; Schatz, undated; Seyani, 1991; Thiel & Bedel, 1973.

Authors M. Brink

DOMBEYA MOLLIS Hook.

Protologue Bot. Mag. 77: t. 4578 (1851).

Family Sterculiaceae (APG: Malvaceae)

Origin and geographic distribution *Dombeya mollis* is distributed in Madagascar, where it occurs in the central and eastern parts of the country. It is sometimes planted elsewhere as an ornamental.

Uses The bark is used for tying, and the bark fibre for making rope and coarse textiles. The leaves are used as toilet paper for children. The wood is used for construction and for making a range of articles, such as mandolins, drums and other musical instruments, hollow cylinders for bellows in smithies and measuring tools for rice. The plant has ornamental value.

Properties The wood is white, lightweight and soft, and it works well.

Botany Shrub or small tree up to 12 m tall; all parts densely stellate hairy; branches cylindrical, densely covered with stellate hairs.

Leaves alternate, simple; stipules ovate-lanceolate, 12–14 mm × 4–6 mm, acuminate, persistent; petiole up to 13.5 cm long, stellate hairy; blade broadly ovate, undivided to 3-lobed, up to 35 cm × 25 cm, base deeply cordate, lobes triangular, acuminate at apex, margin irregularly toothed, more or less bullate, lower surface paler than upper one, both surfaces covered with stellate hairs, palmately veined with 5–9 basal veins. Inflorescence an axillary umbel c. 20 cm long, often with narrowly lanceolate bracts 5–6 mm long, many-flowered. Flowers bisexual, regular, 5-merous; pedicel slender, 2–10 mm long; epicalyx bracts 3, narrowly linear, c. 5 mm long; calyx deeply 5-lobed, hairy outside, glabrous inside, lobes lanceolate or lanceolate-linear, 4–9 mm long, acuminate; petals free, narrowly obovate, asymmetrical, c. 7 mm × 2–3 mm, pinkish, persistent on fruit; androecium utricle-shaped, stamens 15, filaments unequal, 0.5–2 mm long, free or connate above the utricle, alternating with 5 staminodes 3.5 mm long; ovary superior, hairy, stylar column 1.5–2 mm long, with 5 branches c. 2 mm long. Fruit a loculicidal capsule.

Dombeya comprises about 200 species, mainly distributed in Madagascar, with about 20 species in mainland Africa and 14 in the Mascarenes. Revisions of the genus have been carried out for mainland Africa and the Mascarenes, but not for Madagascar, and the number of species described for Madagascar is possibly too high.

In Madagascar the bark and bark fibre of various other endemic *Dombeya* species are used in similar ways as those of *Dombeya mollis*, such as *Dombeya macrantha* Baker, a shrub or small tree up to 5 m tall, sometimes cultivated, *Dombeya magnifolia* Arènes, a shrub up to 6 m tall, *Dombeya megaphyllopsis* Hochr., a small to medium-sized tree up to 18 m tall, and *Dombeya modestiformis* Arènes.

Ecology *Dombeya mollis* occurs from sea-level up to 1600 m altitude in forest, rocky places, along rivers and in disturbed locations. It is an important tree component of evergreen forest in highland Madagascar.

Management *Dombeya mollis* is often planted or spared around villages because the fibre from its bark is considered very useful. It can be propagated by seed or cuttings. Formerly the bark was beaten with a mallet to obtain barkcloth, later the fibre was extracted by crushing the bark, after which the fibre was combed or scutched, making it suitable for spinning and weaving. Fibre extraction was traditionally done by women.

Genetic resources and breeding *Dombeya mollis* is unlikely to be threatened with genetic erosion, as it occurs in disturbed habitats and it is often planted.

Prospects *Dombeya mollis* is considered a very useful local source of material for tying and rope making, resulting in the species being planted or spared around villages. Detailed information on the fibre properties is lacking, however, making it is difficult to assess the prospects of this species.

Major references Arènes, 1959; Boiteau, Boiteau & Allorge-Boiteau, 1999; Huxley (Editor), 1992b; Nagasaki, 2005.

Other references Decary, 1946; Gade, 1996; Missouri Botanical Garden, undated; Schatz, undated; Seyani, 1991.

Authors M. Brink

DOMBEYA MONTANA (Hochr.) Arènes

Protologue Candollea 16: 357 (1958).

Family Sterculiaceae (APG: Malvaceae)

Origin and geographic distribution *Dombeya montana* is endemic to Madagascar.

Uses The bark fibre is used for making rope. Properly prepared, it can be woven in the same way as jute. The bark is used for tying, and was formerly made into barkcloth.

Properties The bark fibre is recorded to be of good quality. The wood is white, soft and brittle.

Botany Small to medium-sized tree up to 20 m tall; young branches densely hispid, older ones glabrous with a blackish bark. Leaves alternate, simple; stipules ovate or suborbicular, 10–14 mm × 5–10 mm, acuminate, long-hairy, persistent; petiole 2.5–5 cm long, cylindrical, densely hairy; blade ovate-suborbicular, unlobed or 3-lobed, up to 13(–30) cm × 11(–30) cm, lobes small, broadly triangular, attenuate-acute, margin finely toothed or almost entire, bullate, both surfaces stellate hairy and velvety, discolorous, lower surface greyish, palmately veined with 5–7 basal veins, prominent on both surfaces. Inflorescence an axillary umbel, many-flowered; axis simple, up to 10 cm long, densely hairy, with many glands. Flowers bisexual, regular, 5-merous; pedicel c.1 cm long, hairy, with many glands; epicalyx bracts 3, elliptical or suborbicular, 13 mm × 4 mm, acuminate, densely long-hairy, caducous; calyx deeply 5-fid, lobes ovate, 7–8 mm long, hairy outside, not reflexed; petals free, asymmetrical, broadly obovate, 15–18 mm × 14–20 mm, white to pink; androecium utricle-shaped, utricle c. 5 mm long, stamens 15, filaments unequal, 0.5–1.5 mm long, free above the utricle, alternating by 3 with 5 staminodes 4.5–6 mm long; ovary superior, hairy, stylar column 7–10 mm long, with 5 branches 1.5–2 mm long. Fruit a loculicidal capsule.

Dombeya comprises about 200 species, mainly distributed in Madagascar, with about 20 species in mainland Africa and 14 in the Mascarenes. Revisions of the genus have been carried out for mainland Africa and the Mascarenes, but not for Madagascar, and the number of species described for Madagascar is possibly too high.

Other *Dombeya* species endemic to Madagascar with barks yielding good rope-making fibre include *Dombeya mandoavato* Arènes, a shrub or tree, *Dombeya mangorensis* Arènes, a small tree, *Dombeya meneriky* Arènes, a tree up to 9 m tall, *Dombeya merika* Arènes, a tree up to 20 m tall, and *Dombeya rottleroides* Baill., a shrub or tree up to 20 m tall.

Ecology *Dombeya montana* occurs in forest from sea level up to 1800 m altitude.

Management Formerly the bark was beaten with a mallet to obtain barkcloth, later the fibre was extracted by crushing the bark, after which the fibre was combed or scutched, making it suitable for spinning and weaving.

Genetic resources and breeding It is unknown whether *Dombeya montana* is threatened by genetic erosion.

Prospects *Dombeya montana* is a useful local source of material for tying and rope making, but detailed information on the extent of its use and the properties of its fibre is lacking, making it difficult to assess the prospects of this species.

Major references Arènes, 1959; Boiteau, Boiteau & Allorge-Boiteau, 1999.

Other references Missouri Botanical Garden, undated; Schatz, undated; Seyani, 1991.

Authors M. Brink

DOMBEYA PILOSA Cordem.

Protologue Fl. Réunion: 312 (1895).

Family Sterculiaceae (APG: Malvaceae)

Vernacular names Mahot, mahot blanc, grand mahot blanc, bois de senteur (Fr).

Origin and geographic distribution *Dombeya pilosa* is endemic to Réunion.

Uses The bark fibre is used for tying, and sometimes trees are found with strips of bark removed. The wood is not very important, but can be used in construction.

Properties The wood is lightweight and not durable. Flowering trees have ornamental value, especially the male ones, which have larger flowers that fall before withering and turning brown. Methanolic extracts of the leaf and stem have shown some radical scavenging and antioxidant activity.

Botany Dioecious, small to medium-sized tree up to 20 m tall; bole up to 70 cm in diameter; outer bark grey, more or less smooth; all growing organs sticky and covered with a white indumentum of stellate and simple hairs 2–3 mm long. Leaves alternate, simple; stipules triangular, 1.5 mm long, sparsely hairy, covered with numerous glands with a sticky exudate, fairly persistent; petiole 5–12 cm long, often with simple hairs, rarely almost glabrous; blade broadly ovate, 6–12(–18) cm × 5–10(–13) cm, base deeply cordate, apex long-acuminate, margin toothed, both surfaces sparsely covered with stellate and simple hairs, palmately veined. Inflorescence an axillary, dense, umbelliform cyme, often completely spherical, 4–9 cm in diameter, the female ones smaller than the male, up to 50-flowered; peduncle 7–16(–19) cm long, hairy, sometimes with 2(–4) large bracts at the apex. Flowers unisexual, regular, 5-merous; pedicel slender, 1–2 cm long, hairy, glandular; epicalyx bracts 3, triangular or ovate, 10–13 mm long, with a long acumen, sparsely covered with simple hairs, caducous; sepals valvate, petals white or pale pink; male flowers c. 2 cm in diameter, sepals 6–8 mm long, apiculate, hairy outside, glabrous inside, petals 9–13 mm long, androecium 9–11 mm long, staminal tube 1 mm long, gynoecium sterile and 5–6 mm long; female flowers 1–1.5 cm in diameter, sepals c. 5 mm long, petals 6–7 mm long, androecium sterile and 3–5 mm long, staminal tube 0.5–1.5 mm long, ovary superior, whitish hairy, 5-celled, style short. Fruit a capsule, reddish, 5–10-seeded.

Flowering is mainly in February–March, but it sometimes occurs earlier and may extend into July.

Dombeya comprises about 200 species, mainly distributed in Madagascar, with about 20 species in mainland Africa and 14 in the Mascarenes. Revisions of the genus have been carried out for mainland Africa and the Mascarenes, but not for Madagascar, and the number of species described for Madagascar is possibly too high.

Dombeya umbellata Cav. ('mahot blanc', 'mahot des hauts') is a small tree up to 15 m tall, endemic to Réunion. Its bark has been used for making rope and rough tissue, and the lightweight wood for making rafts. The species has become rare, however.

Dombeya reclinata Cordem. ('mahot rouge', 'bois de senteur rouge') is a small tree up to 10 m tall, endemic to Réunion. Its fibrous bark is used for tying faggots, and its white and lightweight wood for cabinet work.

Ecology *Dombeya pilosa* occurs fairly commonly in humid forest and other moist locations at (500–)1000–1500(–1900) m altitude.

Genetic resources and breeding *Dombeya pilosa* is fairly common in Réunion, but does not occur elsewhere. It hybridizes with *Dombeya ficulnea* Baillon.

Prospects *Dombeya pilosa* is a useful local source of tying material, but its importance is unlikely to increase.

Major references Association Flore Réunion, 2001; Chan Ng Yok, 2009; Friedmann, 1987.

Other references Medina, 1959; Poullain, Girard-Valenciennes & Smadja, 2004; Seyani, 1991.

Authors M. Brink

DOMBEYA QUINQUESETA (Delile) Exell

Protologue Journ. Bot. 73: 263 (1935).

Family Sterculiaceae (APG: Malvaceae)

Synonyms *Dombeya multiflora* (Endl.) Planch (1850).

Origin and geographic distribution *Dombeya quinqueseta* is distributed from Senegal and Gambia eastward to Eritrea, Ethiopia and Kenya.

Uses The bark is used for tying and for making cordage. In DR Congo it is retted to obtain ribbons similar to raffia. The wood is used for poles and as fuelwood. Ash from the bark yields a vegetable salt. The fruit is a famine food in Sudan.

In African traditional medicine a maceration of the root is taken for the treatment of fever, and decoctions of the root are drunk against fever and stomach-ache. A decoction of the root bark is drunk to treat schistosomiasis. The root and the leaf are used against dizziness. The stem bark is used for the treatment of malaria. A decoction of the stem bark is used as an antidote for snake-bites. The bark is also credited with insecticidal properties.

Properties Per 100 g dry matter the fruit contains: crude protein 6.0 g, fat 0.1 g, soluble carbohydrate 78.2 g, crude fibre 6.3 g, Ca 260 mg, Mg 130 mg, Fe 17.0 mg and Zn 2.1 mg. The essential amino acid composition per 100 g protein (16 g N) is: lysine 2.7 g, methionine 0.8 g, phenylalanine 3.0 g, threonine 3.0 g, valine 3.7 g, leucine 4.5 g and isoleucine 3.0 g. The leaves are said to be poisonous for cattle.

Botany Shrub or small tree up to 12 m tall; outer bark rough and more or less cracked, grey to pale brown, flaking off in small irregular patches; crown open and irregular; inner bark orange-red; branches more or less erect, twisted, terete, covered with stellate, simple, glandular hairs or glabrous. Leaves alternate, simple; stipules oblong, 3–9 mm × 1–3 mm, acuminate, sparsely hairy, caducous; petiole 2–17 cm long, glabrous or hairy; blade ovate to orbicular, sometimes shallowly 3(–5)-lobed, 4.5–24.5 cm × 2.5–21.5 cm, base usually deeply cordate, apex acuminate, margin irregularly toothed, upper surface slightly rough, lower surface tomentose to puberulous. Inflorescence a compound racemoid cyme, 2–4 together on leafless shoots up to 20 cm long arising from the axils of usually fallen leaves, 4–19 cm long, branches forking 3–4 times; peduncle 1–9.5(–14.5) cm long; bracts 1–3 mm × up to 1 mm, hairy, caducous. Flowers bisexual, regular, 5-merous; pedicel 5–18(–35) mm long; epicalyx bracts inserted on pedicel, linear-lanceolate, 1–2 mm long, caducous; calyx lobes reflexed, lanceolate, 4–9 mm × 1–3 mm, hairy; petals spreading, 8–17 mm × 4–8 mm, white to pink or purple, persistent and papery in fruit; androecium 6–10 mm long, stamens 10–15, in a single whorl, up to 7 mm long, alternating with 5 staminodes 5–10 mm long, all filaments united into a staminal tube c. 1 mm long dilating towards the apex; ovary superior, globose, hairy, 3-celled, style 1–3 mm long, 3-branched, densely hairy. Fruit an ovoid to globose capsule c. 5 mm in diameter, hairy. Seeds c. 3 mm long, dark brown.

Dombeya quinqueseta usually flowers in the middle of the dry season, when the leaves are shed. In southern Sudan, for instance, flowering is in the second half of February, and new leaves appear around the end of March. In Benin flowering and fruiting is in November–April.

Dombeya comprises about 200 species, mainly distributed in Madagascar, with about 20 species in mainland Africa and 14 in the Mascarenes. Revisions of the genus have been carried out for mainland Africa and the Mascarenes, but not for Madagascar, and the number of species described for Madagascar is possibly too high.

Ecology *Dombeya quinqueseta* occurs up to 1900(–2200) m altitude in grassland, bushland, wooded grassland and woodland.

Genetic resources and breeding As *Dombeya quinqueseta* is widespread and common, it is not threatened with genetic erosion.

Prospects *Dombeya quinqueseta* has a range of uses, not only being a source of fibre, but also providing famine food, salt, poles, firewood and traditional medicines. Except for the nutritional value of the fruit, no detailed information is available on the properties, making assessment of the prospects of *Dombeya quinqueseta* difficult.

Major references Arbonnier, 2004; Burkill, 2000; Cheek & Dorr, 2007; Seyani, 1991; Vollesen, 1995b.

Other references Akoègninou, van der Burg & van der Maesen, 2006; Chevalier, 1951; Freedman, 1998; Germain & Bamps, 1963; Kokwaro, 1993; Lawani, 2007; Mahmoud et al., 1995; Neuwinger, 2000; Sommerlatte & Sommerlatte, 1990; Van den Eynden, Van Damme & de Wolf, 1994.

Authors M. Brink

DOMBEYA ROTUNDA Arènes

Protologue Candollea 16: 310 (1958).

Family Sterculiaceae (APG: Malvaceae)

Origin and geographic distribution *Dombeya rotunda* is endemic to Madagascar, where it occurs in the western and central parts of the country.

Uses The bark fibre is used for cordage. The bark was formerly made into barkcloth. The wood is made into articles such as hollow cylinders for bellows in smithies, measuring tools for rice, and drums.

Properties The wood is white, lightweight and soft, and it works well.

Botany Tree with young branches ferruginous-hairy, older branches with a greyish bark and small, brown stellate hairs. Leaves alternate, simple; stipules ovate, 12–15 mm × 4 mm, long-acuminate, ferruginous-hairy, caducous; petiole up to 10 cm long, cylindrical, ferruginous-hairy; blade suborbicular, up to 16 cm × 16 cm, base deeply cordate, apex 1–3-cuspidate, margin coarsely and irregularly toothed, both surfaces covered with glandular stellate hairs, but lower surface more densely than upper one, palmately veined with 9 basal veins, venation prominent below. Inflorescence an axillary umbel, with ferruginous stellate hairs, 2–7-flowered; axis simple or bifurcated; bracts ovate, c. 6 mm long, acuminate, stellate-hairy, persistent. Flowers bisexual, regular, 5-merous; pedicel 10–20 mm long; epicalyx bracts 3, ovate, 15 mm × 4 mm, long-acuminate, persistent; calyx deeply 5-fid, lobes triangular, c. 20 mm × 4 mm, apex acuminate, densely glandular outside, ultimately reflexed; petals free, obovate-suborbicular, 20–22 mm × 15–18 mm, papillose; androecium tube-shaped, staminal tube 5–6 mm long, stamens 15, filaments unequal, 1–4 mm long, alternating by 3 with 5 staminodes 10–12 mm long; ovary superior, hairy, stylar column 14–15 mm long, with 5 branches 2.5–5.5 mm long. Fruit a subglobular capsule 10–12 mm long, papillose, stellate-hairy, loculicidal. Seeds ovoid, 3 mm × 2 mm, obliquely truncate, brown, shiny.

Dombeya comprises about 200 species, mainly distributed in Madagascar, with about 20 species in mainland Africa and 14 in the Mascarenes. Revisions of the genus hav been carried out for mainland Africa and the Mascarenes, but not for Madagascar, and the number of species described for Madagascar is possibly too high.

Various other *Dombeya* species endemic to Madagascar are used as fibre plants. The bark fibre of *Dombeya perrieri* Arènes, a tree, can be used for cordage or rough sacks. The fibre of *Dombeya pubescens* (Hochr.) Arènes, a shrub or small to medium-sized tree up to 25 m tall, is used much in the same way as that of *Dombeya rotunda*. The bark of *Dombeya selinala* Arènes, a shrub or small tree up to 8 m tall, provides good cordage fibre.

Ecology *Dombeya rotunda* occurs up to c. 800 m altitude, in forest, on rocks and along rivers.

Management Formerly the bark was beaten with a mallet to obtain barkcloth, later the fibre was extracted by crushing the bark, after which the fibre was combed or scutched, making it suitable for spinning and weaving.

Genetic resources and breeding It is unknown whether *Dombeya rotunda* is threatened by genetic erosion.

Prospects The bark fibre of *Dombeya rotunda* is locally used for making cordage, and the wood is used for small articles. The absence of detailed information on the extent of its use and the properties of its fibre and wood makes assessment of the prospects of this species difficult.

Major references Arènes, 1959; Boiteau, Boiteau & Allorge-Boiteau, 1999.

Other references Decary, 1946; Missouri Botanical Garden, undated; Schatz, undated; Seyani, 1991.

Authors M. Brink

DOMBEYA SPECTABILIS Bojer

Protologue Rapp. Annuel Trav. Soc. Hist. Nat. Ile Maurice 11: 46–47 (1841).

Family Sterculiaceae (APG: Malvaceae)

Chromosome number $2n = 30$

Origin and geographic distribution *Dombeya spectabilis* is endemic to Madagascar, where it occurs in the eastern and central parts of the country. It has been planted elsewhere as an ornamental.

Uses The bark fibre is used for making cordage. Properly prepared fibres can be woven in the same way as jute. Formerly the bark was made into barkcloth and used for tying captives. The wood is used for carpentry and is suitable for papermaking. The plant has ornamental value.

Properties Reports on the quality of the fibre are inconsistent, ranging from inferior to good. Young plants with a thin bark yield stronger and more beautiful fibre than older trees.

The wood is white to reddish, lightweight, soft and brittle. It has given good results in papermaking experiments.

Botany Deciduous, small to medium-sized tree up to 15(–20) m tall; bole up to 20 cm in diameter; all parts covered with red stellate hairs; young branches angled, older ones rounded and with brown striated bark. Leaves alternate, simple; stipules ovate or linear, up to 6 mm long, caducous; petiole 1–4.5 cm long; blade unlobed, very variable, elliptical to obovate or suborbicular, up to 18 cm × 13 cm, base slightly cordate, apex emarginate to rounded or acuminate, margin sinuate or toothed, coriaceous, thick, upper surface greenish, stellate hairy and shiny, lower surface ferruginous and velvety, palmately veined with 5–7 basal veins. Inflorescence an axillary cyme 12–23 cm long, many-flowered. Flowers bisexual, regular, 5-merous; pedicel 3–15 mm long; epicalyx bracts 3, inserted on pedicel, ovate or linear, 2–3 mm long, caducous; calyx deeply 5-lobed, hairy outside, glabrous inside, lobes ovate-lanceolate, 3–5 mm long, attenuate, not becoming reflexed; petals free, obovate, more or less asymmetrical, 7–13 mm × 3.5–8 mm, white to pink, persistent on fruit; androecium monadelphous, crown-shaped, stamens 12–15, staminal column 0.5–1 mm long, filaments unequal, 1–4 mm long, free or connate above the crown, alternating by 2–3 with 5 staminodes 3–5.5 mm long; ovary superior, hairy, stylar column 0.5–1 mm long, with 2–4 branches 2–3 mm long. Fruit a loculicidal capsule.

The flowers appear when the tree is leafless.

Dombeya comprises about 200 species, mainly distributed in Madagascar, with about 20 species in mainland Africa and 14 in the Mascarenes. Revisions of the genus have been carried out for mainland Africa and the Mascarenes, but not for Madagascar, and the number of species described for Madagascar is possibly too high.

In Madagascar the bark fibre of a range of other endemic *Dombeya* species is used in similar ways as that of *Dombeya spectabilis*, including *Dombeya pentagonalis* Arènes, *Dombeya rubricuspis* Arènes, *Dombeya sahatavyensis* Arènes, *Dombeya stipulacea* Baill., *Dombeya superba* Arènes and *Dombeya tsiapetrokensis* Arènes.

Ecology *Dombeya spectabilis* occurs in forest from sea level up to 1200 m altitude. It is locally common.

Management *Dombeya spectabilis* is often planted around villages. It can be propagated by seed or cuttings. Formerly the bark was beaten with a mallet to obtain barkcloth, later the fibre was extracted by crushing the bark, after which the fibre was combed or scutched, making it suitable for spinning and weaving.

Genetic resources and breeding As *Dombeya spectabilis* is locally common and often planted, the risk of genetic erosion seems low.

Prospects *Dombeya spectabilis* is a useful local source of material for tying and rope making, although reports on the fibre quality are contradictory. As detailed information on the fibre properties is lacking, it is difficult to assess the prospects of this species as a fibre plant. The wood is recorded to have prospects as a raw material for papermaking.

Major references Arènes, 1959; Boiteau, Boiteau & Allorge-Boiteau, 1999; Huxley (Editor), 1992b.

Other references Decary, 1946; Missouri Botanical Garden, undated; Schatz, undated; Seyani, 1991.

Authors M. Brink

DOMBEYA VIBURNIFLOROPSIS Arènes

Protologue Candollea 16: 306 (1958).

Family Sterculiaceae (APG: Malvaceae)

Origin and geographic distribution *Dombeya viburnifloropsis* is endemic to Madagascar.

Uses The bark fibre is used for cordage and weaving.

Botany Small tree up to 10 m tall; young branches finely and densely stellate-hairy, older branches with a brown and glabrous bark. Leaves alternate, simple; stipules ovate-lanceolate, 10–12 mm long, long-acuminate, hairy, caducous; petiole 7–10 cm long, rounded, with stellate and simple hairs; blade 3–5-lobed, up to 14 cm × 16 cm, lobes ovate, apex obtuse or acuminate, base deeply cordate, margin irregularly toothed, both surfaces covered with stellate and simple hairs, but more densely below, palmately veined with up to 9 basal veins, venation prominent, especially below. Inflorescence an axillary umbellate cyme, 10–15 cm long, hairy, many-flowered. Flowers bisexual, regular, 5-merous; epicalyx bracts 3, ovate, reddish hairy, 5–6 mm long, caducous; calyx 5-fid, c. 6 mm long, lobes lanceolate, hairy outside, not reflexed; petals free, narrowly obovate, 10–11 mm × 3–5 mm, white; androecium shortly tube-shaped, staminal tube 2–2.5 mm long, stamens 15, white, filaments unequal, 1–2.5 mm long, not or hardly connected above tube, alternating by 3 with 5 staminodes 4.5–6 mm long; ovary superior, hairy, 4–5-celled, stylar column 3–5 mm long, with 4–5 branches 1.5–2.5 mm long. Fruit a loculicidal capsule.

Dombeya comprises about 200 species, mainly distributed in Madagascar, with about 20 species in mainland Africa and 14 in the Mascarenes. Revisions of the genus have been carried out for mainland Africa and the Mascarenes, but not for Madagascar, and the number of species described for Madagascar is possibly too high.

Various other *Dombeya* species endemic to Madagascar are used as fibre plants. *Dombeya tulearensis* Arènes and *Dombeya urschiana* Arènes yield good bark fibres for rope making, whereas *Dombeya valou* Baill., a tree up to 25 m tall with a bole up to 40 cm in diameter, produces fibres of mediocre quality. Its bark has been used for tying captives. The bark fibre of *Dombeya venosa* Arènes is also used for making rope.

Ecology *Dombeya viburnifloropsis* occurs in forest up to 1200 m altitude.

Management The fibre is usually extracted after retting, and combed.

Genetic resources and breeding The conservation status of *Dombeya viburnifloropsis* is unknown.

Prospects The bark fibre of *Dombeya viburnifloropsis* is locally used for rope making and weaving, but information on its properties and the extent of its use are lacking, making it difficult to assess the prospects of this species.

Major references Arènes, 1959; Boiteau, Boiteau & Allorge-Boiteau, 1999.

Other references Missouri Botanical Garden, undated; Schatz, undated; Seyani, 1991.

Authors M. Brink

DYPSIS FIBROSA (C.H.Wright) Beentje & J.Dransf.

Protologue J.Dransf. & Beentje, The palms of Madagascar: 366 (1995).

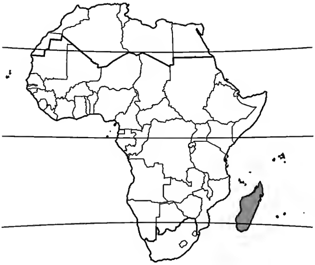
Family Arecaceae (Palmae)

Synonyms *Dictyosperma fibrosum* C.H.Wright (1894), *Vonitra thouarsiana* (Baill.) Becc. (1906), *Vonitra fibrosa* (C.H.Wright) Becc. (1912).

Vernacular names Vonitra palm, mountain vonitra palm (En). Dypsis chevelu (Fr).

Origin and geographic distribution *Dypsis fibrosa* is endemic to Madagascar, where it occurs widely in the north-western and eastern rainforests. It is also grown as an ornamental plant in gardens outside Madagascar.

Uses The leaves are extensively used for thatching. For this purpose leaves of any age can be used provided the leaflets are intact.



Dypsis fibrosa – wild

The leaves are also used for decoration, for instance at religious festivals. The dried inflorescences are widely used as brooms. In this case the entire inflorescence is used with the peduncle serving as shaft. Piassava fibre from the leaf sheath is mainly used for making rope, but also for stuffing mattresses, for scouring pots, and as shoulder pads for porters using carrying-poles. Piassava fibre from *Dypsis fibrosa* and other *Dypsis* spp. from Madagascar ('Madagascar piassava') was formerly used in Europe for industrial brush production, but it has been replaced by synthetic fibres.

The boiled palm heart of *Dypsis fibrosa* is eaten with rice or mixed with other vegetables. Before the widespread availability of manufactured salt, salt was extracted from the pith of the trunk by boiling, and used for seasoning. Insect larvae, that are eaten fried or boiled, are extracted from cut trunks that have been rotting for 2–3 months.

The boiled palm heart and salt from the trunk are used in traditional medicine for the treatment of chronic cough in children. The salt has also been used against intestinal worms and for the treatment of pancreatic disorders caused by malaria.

Outside Madagascar *Dypsis fibrosa* is planted as an ornamental in botanical and private gardens for its mixture of green mature leaves, red young leaves and brown fibres.

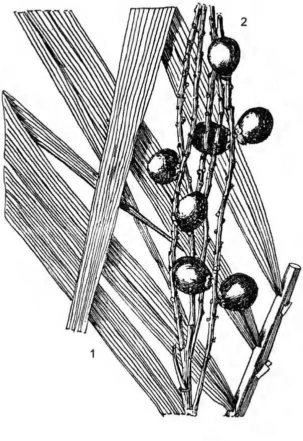
Production and international trade Piassava fibre from *Dypsis fibrosa* was exported in the early 20th century and was an important source of cash income for forest people. Trade of *Dypsis fibrosa* products is presently limited almost exclusively to places in Madagascar where it is common. A panel of five half-leaves bound together for use as thatching material was sold for US$ 0.05 in eastern Madagascar in 1998.

Properties Madagascar piassava is 45–60 cm long, with a rich brown colour. Its softness and flexibility make it suitable for the production of sweeping brooms. The ultimate fibre cells are (0.3–)0.6(–1.3) mm long, with a diameter of (7.5–)10.3(–21) μm. The wood of *Dypsis fibrosa* is hard and white.

Adulterations and substitutes Madagascar piassava can also be obtained from *Dypsis crinita* (Jum. & H.Perrier) Beentje & J.Dransf. and *Dypsis utilis* (Jum.) Beentje & J.Dransf. Other sources of piassava fibre are *Attalea funifera* Mart. ('Bahia piassava' or 'Bahia bass') and *Leopoldinia piassaba* Wallace ('Para piassava' or 'Monkey bass'), both from Brazil, and *Raphia* spp. ('West African piassava'). Madagascar piassava is shorter than Bahia piassava, but finer and more flexible. In the international market, piassava fibre of *Dypsis fibrosa* for the manufacture of brushes has been almost entirely replaced by synthetic fibres such as nylon.

As a source of roof thatch in Madagascar, *Dypsis fibrosa* can be substituted by the traveller's palm (*Ravenala madagascariensis* Sonn.) or other palms with longer leaves than *Dypsis fibrosa*, although *Dypsis fibrosa* is considered superior as thatching material. Thatching material from the palm is also being partially supplanted by use of manufactured materials such as corrugated iron.

Description Palm with solitary trunk or 2–6 trunks clustering in a clump; trunk 3–9 m tall, 5–18 cm in diameter, branched 1–2(–3) times a few meters above the ground, with closely parallel branches, rarely unbranched, base swollen, sometimes with surface roots resembling stilt roots, upper part of trunk covered with fibres, bark pale brown to grey, ringed. Leaves 8–25 in the crown, arching, pinnately compound; sheath 40–60 cm long, red-brown floccose, 10–12 cm wide at the base,



Dypsis fibrosa – 1, mid-section of leaf with leaflets; 2, part of infructescence.
Redrawn and adapted by Iskak Syamsudin

towards the top with a central woody part and a fibrous part with opposite the petiole a pale brown tongue 30–34 cm long becoming tattered and so producing the piassava fibre that clothes the upper part of the trunk, petiole 40–170 cm long, rachis 140–200 cm long; leaflets 34–51 on each side of the rachis, in one plane, dull dark green (red in young leaves), basal leaflets up to 82 cm long, median leaflets up to 71 cm long, upper leaflets up to 42 cm long. Inflorescence between the leaves, branched to 3 orders, arching; peduncle 70–94(–150) cm long, glabrous, green; bracts up to 188 cm long; rachis up to 60 cm long, branches up to 53 cm long (up to 78 cm long in fruit), glabrous, green to red-brown, with the flowers in triads of 1 central female flower and 2 lateral male flowers. Flowers unisexual, 3-merous, orange in bud, yellow at anthesis; male flowers slightly trigonous, with 6 stamens in 2 series and a rudimentary pistil; female flowers globose, with superior ovary and rudimentary stamens. Fruit an obovoid to almost globose drupe 20–30 mm × 18–25 mm, with persistent perianth, 1-seeded. Seed ellipsoid, 20–23 mm × 15–18 mm; endosperm ruminate.

Other botanical information *Dypsis* comprises about 140 species, all endemic to Madagascar except 2 occurring in the Comoros and 1 on Pemba Island. *Dypsis fibrosa* belongs to the 'Vonitra' group within the genus. Palms of this group are characterized by fibrous leaf sheaths that disintegrate into piassava. They are the source of Madagascar piassava, with *Dypsis fibrosa* being the main species harvested. The most robust member of the 'Vonitra' group is *Dypsis utilis* (Jum.) Beentje & J.Dransf. (synonym: *Vonitra utilis* Jum.), a palm with solitary or clustered, branched trunks up to 17 m tall, occurring in eastern Madagascar along streams in moist forest at 950–1000 m altitude. It yields good piassava fibre, the palm heart and fruits are edible, and the wood is used for construction. The species occurs in only a few locations and probably in low numbers, and it is classified as vulnerable in the IUCN Red list of threatened species. *Dypsis crinita* (Jum. & H.Perrier) Beentje & J.Dransf. (synonym: *Vonitra crinita* Jum. & H.Perrier) is a palm with clustering and usually branched trunks up to 15 m tall, occurring in north-western and north-eastern Madagascar along streams at 200–250 m altitude. Its piassava fibre is used for rope making, for mattress stuffing, and for filtering oil. The leaves are used for thatching. The wood is used in traditional medicine against cough in children. The species is rare and is included in the IUCN Red list, where it is considered to be at lower risk although near threatened.

Ecology *Dypsis fibrosa* occurs from sea level up to 800(–1250) m altitude, on steep slopes and ridge tops in moist upland or coastal hill forest, and in littoral or peat swamp forest. *Dypsis fibrosa* is one of only 2 species on which the rare orchid *Cymbidiella falcigera* (Rchb.f.) Garay grows in its native range in south-eastern Madagascar.

Harvesting Leaves are harvested either by removing them from living trees or by felling trunks to strip the leaves. It is common to strip all leaves from a standing tree, and spare only 1 or 2 emerging leaves. The practice of too abundant or too frequent pruning leads to slow growth and postponed maturity. The multi-stem habit means that felling of a trunk is not necessarily fatal for the tree. Piassava fibre is obtained by cutting old leaf sheaths from the trunk. Hence this is a non-destructive harvest. Extraction of heart of palm entails the felling of trunks.

Handling after harvest After the leaves have been harvested, the leaflets are stripped from one side of the leaf, and the remaining half-leaves are used for thatching. Five such half-leaves are bound together to form a panel. For covering a hut of 3 m × 4 m, 500 panels of leaves are needed. A roof thatched with leaves of *Dypsis fibrosa* lasts up to 5 years, but in houses with fireplaces the thatch lasts 10–20 years thanks to the insect-deterring action of smoke and soot from the fire.

Genetic resources *Dypsis fibrosa* is not threatened. Its wide distribution in Madagascar, as well as its use in gardens in other parts of the world, means that for the moment there is no major threat of extinction or genetic erosion. Also, its multi-stem habit allows it to withstand felling of a trunk without dying. However, in a survey in eastern Madagascar where the tree is heavily exploited for use of its leaves for thatching, it was found that its population is declining. It was indicated that the population structure is changing as well, with a large proportion of trees kept in a juvenile growth pattern due to the constant harvesting of outer leaves. In the same survey, it was revealed that local villagers do not favour sustainable harvesting measures of *Dypsis fibrosa* but prefer to switch to alternative thatching materials (other palms or corrugated tin) once *Dypsis fibrosa* thatch becomes scarce. Therefore, *Dypsis fibrosa* may soon become locally threatened unless conservation or sustainable exploitation measures are implemented.

Prospects The popularity of *Dypsis fibrosa* as a source of thatching material leads to unsustainable exploitation practices, and the species may become locally threatened soon. A possible way to avoid this and to conserve the species while maintaining its use by people, would be to encourage its planting in home gardens and fields and subsequently its commercialization. The importance of piassava fibre from *Dypsis fibrosa* for the manufacture of brushes is unlikely to increase again, due to competition from synthetic fibres and other sources of piassava fibre.

Major references Boiteau, Boiteau & Allorge-Boiteau, 1999; Byg & Balslev, 2001a; Byg & Balslev, 2001b; Dransfield & Beentje, 1995; Kirby, 1950; Kirby, 1963; Uhl & Dransfield, 1987.

Other references Byg & Balslev, 2003; Decary, 1946; Dransfield & Beentje, 1998a; Goulding, 1917; Gray, undated; Johnson, 1998a; Johnson, 1998d; Jumelle, 1945; Medina, 1959; Missouri Botanical Garden, undated; Porembski, 2003; Riffle & Craft, 2003.

Sources of illustration Jumelle, 1945.

Authors G. Vaughan

DYPSIS LASTELLIANA (Baill.) Beentje & J.Dransf.

Protologue J.Dransf. & Beentje, The palms of Madagascar: 175 (1995).

Family Arecaceae (Palmae)

Synonyms *Neodypsis lastelliana* Baill. (1894).

Vernacular names Redneck palm, teddy bear palm (En). Palmier à col rouge (Fr).

Origin and geographic distribution *Dypsis lastelliana* is distributed in north-western, north-eastern and eastern Madagascar. It is grown outside Madagascar as an ornamental.

Uses The leaves are used for thatching, the petioles for rice trays, and the hairs covering the leaf sheath for stuffing. The leaves are also used for decoration, for instance of churches and village entrances. Formerly salt was extracted from the pith and used for seasoning and as a cough medicine. Edible larvae are collected from the trunks. The plant is grown as an ornamental.

Properties The palm heart is bitter and inedible; it is said to be poisonous. The palm has ornamental value, particularly because of its densely red-brown hairy crown shaft.

Botany Palm with solitary trunk up to 15 m tall, 18–25 cm in diameter, base swollen; crown shaft 70–75 cm long, velvety red-brown. Leaves 9–15 in the crown, arranged spirally, pinnately compound; sheath 40–60 cm long, partially open, brilliantly red adaxially, densely red-brown pubescent abaxially, petiole up to 10 cm long, rachis up to 380 cm long; leaflets (50–)94–102 on each side of the rachis, regular, somewhat pendulous, basal leaflets up to 66 cm long, median leaflets up to 89 cm long, upper leaflets up to 54 cm long. Inflorescence between the leaves, branched to 3 orders, spreading; peduncle 60–96 cm long; bracts up to 110 cm long; rachis c. 97 cm long, branches up to 47 cm long, glabrous, pale or yellowish green, with the flowers in triads of 1 central female flower and 2 lateral male flowers. Flowers unisexual, 3-merous; male flowers with 6 slightly biseriate stamens and a rudimentary pistil; female flowers with superior ovary and rudimentary stamens. Fruit an obovoid drupe 18–24 mm × 12–17 mm, slightly asymmetrical, 1-seeded. Seed ovoid, 12–21 mm × 10.5–16 mm; endosperm deeply ruminate.

Dypsis comprises about 140 species, all endemic to Madagascar except 2 occurring in the Comoros and 1 on Pemba Island. Various *Dypsis* species are used as fibre plants. *Dypsis perrieri* (Jum.) Beentje & J.Dransf. (synonyms: *Antongilia perrieri* Jum., *Chrysalidocarpus auriculatus* Jum., *Chrysalidocarpus ruber* Jum.) is a palm with a single trunk up to 8 m tall, occurring at 150–800 m altitude in moist forest. Its leaves are used for thatching and decoration, and hairs from the leaf sheaths and bracts are used for stuffing mattresses. It yields good palm heart and is also tapped for palm wine. The species is classified as vulnerable in the IUCN Red list, because it is uncommon wherever it occurs, and overexploitation of the palm heart is a major threat. The split stems of *Dypsis scandens* J.Dransf., a climbing palm with stems up to 10 m long, are used for making fish traps, bird cages and hats. The species is probably endangered, because it is only known from a single, unprotected location. *Dypsis tanalensis* (Jum. & H.Perrier) Beentje & J.Dransf. (synonym: *Neodypsis tanalensis* Jum. & H.Perrier) is a palm with a trunk up to 20 m tall. It has been used for cordage, and the trunk has been used for carrying loads and for making blowpipes. As the species had not been collected for almost a century, it was thought to be extinct, but recently it was rediscovered. *Dypsis thermarum* J.Dransf. is a palm with solitary or clustering trunks up to 2 m tall, occurring at 800–1400 m altitude in Ranomafana National Park. Its stems are used for making traps to catch crayfish. The species is rare. The leaves of *Dypsis tokoravina* Beentje is a large palm with a solitary trunk up to 20 m tall have been used for weaving and the palm heart has been eaten, but the species is only known from two populations and is endangered.

Ecology *Dypsis lastelliana* occurs from sea-level up to 450 m altitude in moist forest on slopes, often in rather open forest or near forest margins, or near water, in ravines, also in coastal forest on white sand. Its cultivation requires a subtropical to tropical climate. It can be grown in full sun.

Management The seeds germinate in 2–4 months.

Genetic resources and breeding *Dypsis lastelliana* is not threatened, as it occurs widespread in Madagascar, and it is cultivated elsewhere.

Prospects As a fibre plant *Dypsis lastelliana* will probably remain of limited local importance. As an ornamental plant it may spread further in tropical and subtropical regions, but it has potential for the humid tropics in particular.

Major references Boiteau, Boiteau & Allorge-Boiteau, 1999; Byg & Balslev, 2001a; Dransfield & Beentje, 1995; Ellison & Ellison, 2001; Riffle & Craft, 2003.

Other references Byg & Balslev, 2003; Decary, 1946; Dransfield, 1999; Johnson, 1998b; Jumelle, 1945; Medina, 1959; Missouri Botanical Garden, undated; Rakotoarinivo & Dransfield, 2010.

Authors M. Brink

EFULENSIA MONTANA W.J.De Wilde

Protologue Blumea 22: 34 (1974).

Family Passifloraceae

Origin and geographic distribution *Efulensia montana* occurs in DR Congo and Uganda.

Uses The Nyindu people in DR Congo use the vines as lashings in house construction and for making animal traps and similar products. The vines are also split and used for making flat baskets.

Botany Robust, glabrous liana up to 20 m long, stem c. 0.5 cm in diameter. Tendrils simple, 8–20(–25) cm long, sometimes absent. Leaves 5-foliolate, palmate to imparipinnate; petiole (1.5–)2–8 cm long, bearing 2 glands 0.5–2.5 cm above the base; the lowest pair of leaflets inserted at a distance of up to 3 mm from top leaflets; petiolules 0.5–1.5 cm long; leaflets elliptical to oblong, (1.5–)2.5–10 cm × (0.5–)1–3.5 cm, base subobtuse to acute, apex mostly acute and acuminate, rarely subobtuse, margin entire, papery, bearing up to 6 glands up to 0.5 mm in diameter at each side on the margin close to the base. Inflorescence axillary, cymose, 2–6(–8)-flowered, often terminating in a tendril; peduncle 5–13 cm long; bracts minute. Flowers bisexual or functionally male, 5-merous, greenish or whitish; petiole very short; stipe 7–25 mm long; sepals free, oblong-ovate, 7–10 mm × 2.5–3 mm, obtuse; petals free, oblong to oblong-ovate, 7–9 mm × 2–2.5 mm, acute to obtuse; corona 3.5–6 mm long, consisting of tube 1.5–2 mm long and threads 2–5 mm long; stamens 5, filaments 3–7 mm long, joint at the base, anthers 2.5–3.5 mm long, sometimes apiculate; ovary in bisexual flowers ellipsoid, 2.5–3.5 mm × c. 1.5 mm, styles 3, 1.5–3.5 mm long, connate for 0.5–1.5 mm, free for 0.5–1 mm, stigmas globular, ovary in male flowers much reduced and 1.5–2 mm long. Fruit a woody capsule, 1–4 together, ellipsoid, 2–4 cm × 1.5–2.5 cm, obtuse to subacute at both ends; with 3 wide grooves and 3 valves 2.5–3 mm thick at the sutures, 6–12-seeded. Seeds c. 6 mm × 5 mm, with 3–4 pits across the length.

Efulensia is a small genus of 2 species in tropical Africa. *Efulensia clematoides* C.H.Wright is used as a medicinal plant. *Efulensia* was formerly included in *Deidamia* from Madagascar, which it resembles very much in habit and by the 3- or 5-foliolate leaves. *Deidamia commersoniana* DC., a liana up to 20 m long, yields fibre of fair durability.

Ecology *Efulensia montana* occurs in rainforest at 850–2000 m altitude.

Management The plants are only collected from the wild.

Genetic resources and breeding *Efulensia montana* does not seem to be in danger of genetic erosion.

Prospects *Efulensia montana* will probably remain a fibre plant of local value only. As the only other *Efulensia* species is used as a medicinal plant, it might be interesting to conduct research on the medicinal uses and properties of *Efulensia montana*.

Major references de Wilde, 1974; de Wilde, 1975; Robyns, 1995; Yamada, 1984; Yamada, 1999.

Other references Decary, 1946; Feuillet & MacDougal, 2007; Perrier de la Bâthie, 1945; Yamagiwa et al., 1994.

Authors L.P.A. Oyen

ELYMANDRA ANDROPHILA (Stapf) Stapf

Protologue Oliv., Fl. Trop. Afr. 9(3): 408 (1919).

Family Poaceae (Gramineae)

Chromosome number 2*n* = 20

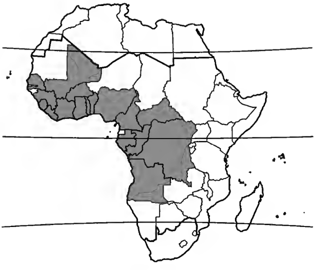
Synonyms *Andropogon androphilus* Stapf (1881).

Origin and geographic distribution *Elymandra androphila* occurs widely dispersed in West Africa from Senegal eastward to Cameroon and the Central African Republic, and extending southwards through the Congo basin to Angola.

Uses In Sierra Leone the stems of *Elymandra androphila* are valued for thatching, considered second best only to those of *Danthoniopsis chevalieri* A.Camus & C.E.Hubb. *Elymandra androphila* is also a good forage grass.

Production and international trade *Elymandra androphila* is only used and traded locally.

Botany Perennial, coarse, tufted grass; stems erect, up to 2.5 m tall and up to 5 mm in diameter, glabrous, yellow, with black roots from lower nodes, branched from upper nodes. Leaves alternate; sheath glabrous, long-hairy along the margins near the apex; ligule membranous, truncate, 1–2 mm long, pale brown, minutely ciliolate on the margin, flanked on either side by tufts of long white hairs from the base of the blade; blade linear, up to 60 cm × 9 mm, flat or folded, tapering to a fine point, harshly scabrid on the upper surface and margins, glabrous, glaucous. Inflorescence a terminal or axillary, narrow, lax, compound false panicle up to 60 cm long, composed of racemes; spatheole linear, up to 10 cm long, tightly rolled around peduncle, green, glabrous; peduncle filiform, yellow, scabrid or puberulous near the tip; racemes 2, paired, 2–3 cm long, 2-awned per pair, densely packed with spikelets; raceme-bases glabrous, the lower 1–2 mm long, the upper 15–25 mm long. Spikelets in pairs, one sessile and fertile, one pedicelled and sterile; at the base of each raceme (2–)5–7(–9) homogamous pairs of spikelets; homogamous spikelets narrowly lanceolate, 6–8 mm long, acute to acuminate, glabrous; pedicels and internodes glabrescent, ultimately disarticulating between each pair and falling with the spikelets attached; sessile spikelet linear-oblong, 7–10 mm long (including callus), callus 2–3 mm long, pungent, bearded with white hairs, lower glume elliptical, upper glume lanceolate and acute, rarely with an awn up to 3 mm long, lower floret reduced to hyaline lemma, upper floret bisexual, fertile lemma 5 mm long with awn (5.5–)7(–9) cm long, the column densely puberulous, palea absent or minute, stigmas 2; pedicelled spikelet narrowly lanceolate, 7–11 mm long, pedicel 6–10 mm long (excluding callus) and glabrous, the tip acuminate and often with a short bristle, callus oblong, 1–1.5 mm long, obliquely truncate at the base. Fruit a caryopsis.



Elymandra androphila – wild

Elymandra is a genus classified in the *Andropogoneae*, comprising 6 species with a centre of diversity in West Africa, and extending southward and eastward to Namibia, Tanzania and Zimbabwe.

Ecology *Elymandra androphila* is a grass of poor sandy soils in uncultivated guinean and sudanese savanna, occurring up to 2000 m altitude in the Bamenda highlands in western Cameroon. It occurs typically on plateaus and stony hillsides, but also on shallow soils over ironstone pans and on lower slopes. It is affected by grazing: in a *Borassus aethiopum* Mart. palm savanna on ferruginous soil in Côte d'Ivoire the proportion of *Elymandra androphila* in the vegetation on ungrazed plateau land was 19%, and on grazed land only 5%; at the bottom of slopes the proportions were 23% and 12%, respectively.

Management *Elymandra androphila* only occurs wild.

Genetic resources and breeding As *Ely-*

mandra androphila is widespread and common, it is not in danger of genetic erosion.

Prospects *Elymandra androphila* is likely to remain a source of thatch of local importance and a valuable forage component in natural grasslands.

Major references Burkill, 1994; Clayton, 1966c; Clayton, 1972; Poilecot, 1995; van der Zon, 1992.

Other references Boudet, 1963; César, 1975; Clayton, Harman & Williamson, 2002–; Kammacher et al., 1973; Kindomihou, Sinsin & Meerts, 2006.

Authors L.P.A. Oyen

ENTADA RHEEDEI Spreng.

Protologue Syst. veg. 2: 325 (1825).

Family Mimosaceae (Leguminosae - Mimosoideae)

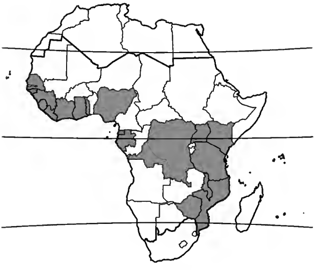
Chromosome number $2n = 28$

Synonyms *Entada pursaetha* DC. (1825).

Vernacular names Sea bean, McKay bean, elephant climber, matchbox bean, Queensland bean (En). Liane sabre, liane staub, liane à bœuf (Fr).

Origin and geographic distribution In tropical Africa *Entada rheedei* is distributed from Guinea Bissau in the west to Kenya, Tanzania and Mozambique in the east. It is also native to South Africa, India to China, Guam and northern Australia. It is cultivated in Mauritius.

Uses The stems of *Entada rheedei* are used as ropes throughout its area of distribution. The bark yields a good fibre for tying and for making fishing lines. In Madagascar the seeds are eaten after being soaked, shelled and cooked. In Madagascar the bark serves as a substitute for soap and elsewhere it is used as a hair wash. The smooth, shiny seeds are used for games. They are also used for polishing various artefacts by rubbing. In Malawi, for instance, the seeds are used for making the surface of clay pots smooth.

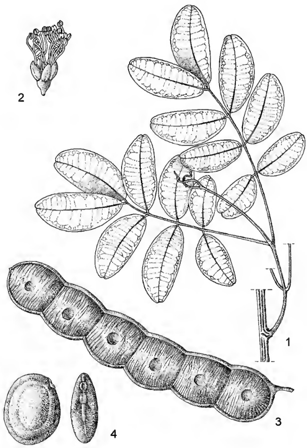


Entada rheedei – wild

In traditional medicine in Tanzania sap from the stem-bark or root is rubbed on the skin as a treatment for an enlarged spleen, and an infusion of the bark is applied as a cure for scabies. The powdered seed is ingested in Ghana as a cure for fever. Decoctions of the seeds are used for soothing sore feet and in Mauritius as anthelmintic and to induce vomiting. The whole plant is considered a febrifuge. In South Africa the seeds are used for the treatment of jaundice and powdered seed is taken as a tonic. In Nepal the whole plant is made into a paste that is taken for relief of painful bones. In South-East Asia the bark and seeds are widely used against pains and itch. The seeds are also used in a poultice to cure colic in children. In Nigeria an infusion of the leaves is used as a fish-poison. The pods are used for fish poison in Katanga (DR Congo).

Properties The bark and seeds contain saponins. The seeds contain tyrosine-O-glucoside, tyramine-O-glucoside and dopamine-3-glucoside.

Description Large liana with unarmed stems over 50 m long; young branches glabrous or short soft-hairy. Leaves alternate, bipinnately compound, with (1–)2 pairs of pinnae; petiole (1–)2.5–4 cm long; rachis 4.5–7 cm long, usually grooved and short-hairy above, with tendrils at the apex; leaflets opposite, in 3–4(–5) pairs per pinna, elliptical to obovate-elliptical, up to 9 cm × 4 cm, obtuse to emarginate at apex, papery, short soft-hairy only on lower side along the basal part of the primary vein. Inflorescence an axillary spike-like raceme up to 30 cm long; peduncle short hairy or glabrous. Flowers bisexual, regular, 5-merous, yellowish-white; pedicel c. 0.5 mm long; calyx cup-shaped, 0.5–1.5 mm long, glabrous; corolla c. 3.5 mm long, with short tube and acute lobes, glabrous; stamens 10, united at base, c. 7 mm long; ovary superior, short-stalked, glabrous, 1-celled, style filiform, 4–5 mm long. Fruit a gigantic, straight or slightly curved pod 0.5–2 m × 7–15 cm, strongly compressed, with a 2–9 cm long stipe, glabrous, with papery blackish brown outer layer peeling off, several-seeded, breaking up into 1-seeded segments. Seeds almost circular, flattened, c. 5 cm × 3.5–5 cm, testa hard, chestnut brown.



Entada rheedei – 1, part of branch with leaves; 2, flower; 3, fruit; 4, seeds.
Redrawn and adapted by Achmad Satiri Nurhaman

Other botanical information *Entada* comprises c. 30 species and is distributed throughout the tropics. About 15 species occur in continental Africa and 6 in Madagascar. Wrong identifications and misapplications of names have led to ample confusion. Especially in the pharmacological literature errors abound. The name *Entada phaseoloides* auct. non (L.) Merr., for instance, is used for specimens from Africa while the name applies to a species that is strictly Asian.

The stems of several *Entada* species yield fibres and are used for tying. *Entada gigas* (L.) Fawc. & Rendle is distributed in West and Central Africa extending into Uganda and Zambia and also in Central America, Colombia and the Caribbean. This species has often been confused in the literature with *Entada rheedei* from which it differs by the spirally twisted pod, the extent of the pubescence and in its ecology (it is confined to fringing forest along rivers). In Gabon the inner bark of *Entada gigas* is retted and the long, durable fibres are extracted to be used for ropes and nets. A bark decoction serves to bathe patients with anaemia and new mothers. It is also considered a cure for gonorrhoea. In DR Congo a decoction of the stem is given to overcome difficulty in breathing and an infusion is a cure for diabetes. For rheumatic patients leaves are warmed and applied to painful areas. A bark decoction is drunk against stomach pain. In Ghana *Entada gigas* is often planted at the entrance of villages to ward off misfortune, danger and accidents.

Entada leptostachya Harms ('mgambari' in Kiswahili) is a liana as well and is restricted to Ethiopia, Somalia, Kenya, Tanzania, the Comoros and Madagascar. In Madagascar the stems are used for tying. In Kenya the bark fibre is used for making rope, the roots are used as a remedy for snakebite, and the stems and roots are sources of potable water. In Ethiopia the twigs are commonly used for the treatment of a number of diseases with fever as a symptom.

Entada mannii (Oliv.) Tisser., a scandent shrub or woody liana, is distributed from Senegal to DR Congo and Angola. The stems are used as tying material in construction in Côte d'Ivoire. In Gabon fibre from the inner bark is used for making belts and harnesses to climb palm trees for wine tapping.

Growth and development *Entada rheedei* is reported to be a symbiotic nitrogen-fixer. In Madagascar it flowers in April and from August to December.

Ecology *Entada rheedei* is most often found in lowland rainforest and fringing forest.

Propagation and planting *Entada rheedei* can be readily grown from cuttings. Natural germination of the hard *Entada* seeds may take a year or more. Seed treatment by removal of the hilum, including a portion of the testa, and germination in a wet jute sack, results in radicle emergence and seeds ready for potting within 15 days. Seedlings can be planted out in the field after 1 month.

Management In south-western DR Congo fallow fields are often enriched by sowing seeds of *Entada* and *Pentaclethra* spp.

Harvesting In Mauritius the seeds are collected on the beaches and are for sale at herbalists on markets.

Genetic resources *Entada rheedei* is widespread and therefore not threatened with extinction or even genetic erosion. However, in south-western DR Congo it is recorded to have become uncommon as a result of overexploitation.

Prospects As a fibre producer *Entada rheedei* may remain important locally. Saponins, diterpenes and entadamines from *Entada rheedei* and related species possess interesting properties as molluscicidal, trypanocidal, anti-asthma and anti-inflammatory compounds. Research is needed to evaluate their potential.

Major references Brenan, 1970; Burkill, 1995; du Puy et al., 2002; Latham, 2004; Nicolson, Suresh & Manilal, 1988; van der Maesen, 2001; Villiers, 1989.

Other references Beentje, 1994b; Boiteau, Boiteau & Allorge-Boiteau, 1999; Brenan, 1959; Brenan, 1967b; Burgess, 2000; Gurib-Fakim, Guého & Bissoondoyal, 1996; Haerdi, 1964; Hegnauer & Hegnauer, 1994; Hutchings et al., 1996; Irvine, 1961; Malaisse, 1997; Medley & Kalibo, 2007; Rasoanaivo, Petitjean & Conan, 1993; Tra Bi, Kouamé & Traoré, 2005; Uprety et al., 2010; Visser, 1975; White & Abernethy, 1997; Wondimu, Asfaw & Kelbessa, 2007.

Sources of illustration Villiers, 1989.

Authors C.H. Bosch

Based on PROSEA 12(2): Medicinal and poisonous plants 2.

ERAGROSTIS PALLENS Hack.

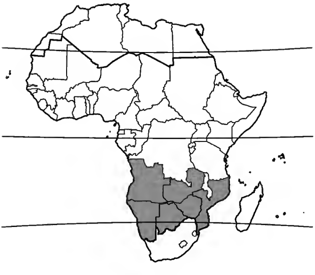
Protologue Bull. Herb. Boissier 3:392 (1895).

Family Poaceae (Gramineae)

Synonyms *Eragrostis dura* Stapf (1898).

Vernacular names Broom grass, broom love grass (En).

Origin and geographic distribution *Eragrostis pallens* occurs in southern Africa, from Angola, Zambia and Mozambique through Namibia, Botswana and Zimbabwe to South Africa.



Eragrostis pallens – wild

Uses The stems of *Eragrostis pallens* are popular for forming the interior of the coils in basketry. The coarse stems are used to hit the string of one-stringed musical instruments to make them sound, such as the okambulumbumbua of the Ovambo in Namibia and Angola, in which a gourd serves as the resonance box. *Eragrostis pallens* is commonly used in northern Botswana and in Ovamboland for thatching and for brooms. As it is a hard and poorly palatable grass, it is rarely eaten by livestock.

Production and international trade *Eragrostis pallens* is only used and traded locally.

Properties Nutritive value tests in Namibia of 2 samples of leaf sheaths and young growth indicated: crude protein 3.2–3.6%, P 0.01–0.03%, Ca 0.20–1.1%, organic matter 95.4–95.8%, dry matter 95.8–96.4%, crude fibre 37.2%, acid detergent fibre (ADF) 47.0%, neutral detergent fibre (NDF) 81.3%, in-vitro digestibility 31.5–41.7%, metabolizable energy 4.2–5.9%.

Botany Perennial, densely tufted grass without rhizome and usually without stolons; stems up to 200 cm tall, 2–4 mm in diameter, robust, erect, branched or unbranched, glabrous at the nodes, without glands. Leaves alternate, mostly at the base of the stem; basal leaf sheaths thinly pilose below or glabrous, firmly papery, terete or lightly laterally compressed, without glands, persistent; ligule a line of hairs; blade linear, 7–40(–100) cm × 3–5(–8) mm, involute, glabrous or thinly pilose, without glands. Inflorescence a narrowly oblong to broadly ovate panicle 8–45 cm long, open, the spikelets subsessile or shortly pedicelled (0.5–1 mm) on the racemose primary branches or on secondary branchlets, the primary branches ascending or spreading, not in whorls, terminating in a fertile spikelet, glabrous in the axils, without glands. Spikelets solitary, narrowly oblong to linear, 5–21 mm × 1.5–2 mm, slightly laterally compressed, with 6–36 florets, the florets disarticulating from the apex downwards, the rachilla fragile; glumes somewhat unequal, lower glume 0.5–1.5 mm long, reaching to about the middle of the adjacent lemma, slightly keeled, narrowly lanceolate to narrowly elliptic in profile, glabrous, subacute or obtuse at the apex, upper glume 1–2 mm long, reaching to about 2/3 the way along the adjacent lemma, slightly keeled, oblong-lanceolate to oblong-

elliptical in profile, glabrous, obtuse at the apex; lemma c. 2 mm long, slightly keeled, ovate-elliptical in profile, subcoriaceous with obscure lateral veins, more or less appressed to the rachilla, those in opposite rows somewhat imbricate and more or less concealing the rachilla, pallid or dark green, glabrous, obtuse at the apex; palea glabrous on the flanks, the keels slender, wingless, scaberulous; anthers 3, 1–1.5 mm long. Fruit an elliptical caryopsis (grain) 0.5–1 mm long.
In South Africa *Eragrostis pallens* flowers in (July–)December–May.
Eragrostis is a large genus comprising about 360 species, and is distributed in the tropics and subtropics.

Ecology *Eragrostis pallens* occurs from sea-level up to 1500 m altitude in floodplain and dambo grasslands, sandveld and wooded short grasslands with mopane or with mixed deciduous trees, on Kalahari sand and other sandy soils. It is a climax grass of the central and northern Kalahari and often occurs in association with *Terminalia sericea* Burch. ex DC. and *Burkea africana* Hook.

Management In South Africa *Eragrostis pallens* is classified as a grass of little grazing value. It is a strong competitor and increases under overgrazing, thereby reducing the quality of grazing land.

Genetic resources and breeding *Eragrostis pallens* is widespread and a locally dominant, strongly competitive grass. It is not in danger of genetic erosion.

Prospects The stems of *Eragrostis pallens* are likely to remain of local value for basketry, thatching and broom-making.

Major references Cope, 1998; Cope, 1999; Rodin, 1985; van Oudtshoorn, 1999; van Wyk & Gericke, 2000.

Other references Dörgeloh, 1999; Gibbs Russell et al., 1990; Kgathi, Mmopelwa & Mosepele, 2005; Klaassen & Craven, 2003; Müller, 1984; Quattrocchi, 2006; SEPASAL, 2003.

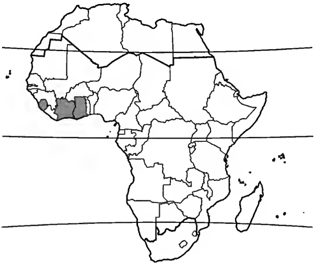
Authors L.P.A. Oyen

EREMOSPATHA DRANSFIELDII Sunderl.

Protologue Kew Bull. 58(4): 988 (2003).

Family Arecaceae (Palmae)

Origin and geographic distribution *Eremospatha dransfieldii* is distributed from Sierra Leone eastwards to Ghana, occurring mainly in eastern Côte d'Ivoire and western Ghana.



Eremospatha dransfieldii – wild

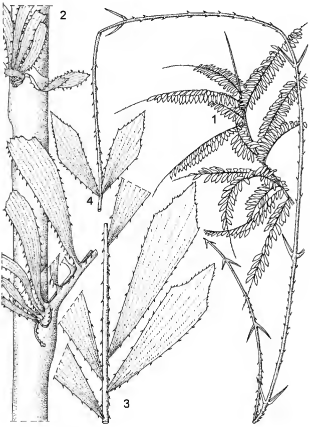
Uses The split stem is a strong tying material, used for house construction, and is widely used for basketry and furniture. The epidermis of the stem is used as rope, for instance for binding the framework of mud houses.

Production and international trade *Eremospatha dransfieldii* is extensively traded, especially in Ghana, primarily in local markets. As is the case with most African rattans, there is inadequate information on the international trade, but it is probably negligible. *Eremospatha dransfieldii* may have been among the species that were exported from Ghana to the United Kingdom in the period between the two World Wars. The amount of all rattan canes supplied to urban markets in West and Central Africa has been estimated at a total length of 340,000 m per month.

Properties The stem is reddish brown and lightweight, with an oven-dry density of 280–440 kg/m³, depending on the position along the stem. The stem is slender, soft and flexible, and is easy to split.

Adulterations and substitutes *Eremospatha dransfieldii* has properties quite similar to those of the commercially more important *Eremospatha macrocarpa* (G.Mann & H.Wendl.) H.Wendl., one of the most favoured commercial rattans in Africa. In Ghana *Calamus deërratus* G.Mann & H.Wendl., a rattan species considered to be of lesser quality than *Eremospatha* spp., is utilized in areas where *Eremospatha* is absent.

Description Clustering, moderate to robust rattan palm forming vigorous clumps; stem up to 40–50 m long, 13–24 mm in diameter without sheaths, 25–30 mm in diameter with



Eremospatha dransfieldii – 1, plant habit; 2, part of stem; 3, part of leaf; 4, apex of leaf. Redrawn and adapted by Achmad Satiri Nurhaman

sheaths, circular in cross section, internodes 10–16 cm long. Leaves up to 3.5 m long, pinnately compound; sheath slightly striate, unarmed, glabrous, often covered with colonies of scale insects; ocrea entire, obliquely truncate, expanding up to 1–2 cm above the leaf junction; petiole absent; rachis 1.2–1.5 m long, abaxially rounded, adaxially convex to concave, becoming trapezoid then triangular in cross-section distally, margins armed with robust, reflexed, yellow-orange spines, rachis distally prolonged into cirrus 1.2–1.5 m long bearing acanthophylls (leaflets modified into reflexed hooks) 3–4 cm long; leaflets up to 40 on each side of the rachis, inequidistant, oppositely to sub-oppositely arranged, highly variable in shape, obovate-elliptic to oblanceolate to rhomboid or spathulate, 12–30 cm × 3.5–5.5 cm, basal leaflets smaller than the others, base obtusely cuneate, apex praemorse, margins armed with yellow to orange spines. Inflorescence, flowers and fruits unknown.

Other botanical information *Eremospatha dransfieldii* was only recently recognised as a species. Formerly specimens were frequently assigned to *Eremospatha hookeri* (G.Mann & H.Wendl.) H.Wendl. *Eremospatha* is one of the three rattan genera endemic to Africa. It comprises 11 species, which are easily distinguished from each other on the basis of vegetative characteristics.

Eremospatha cabrae (T.Durand & Schinz) De Wild. is a slender to moderately robust rattan palm with stems 20–30(–50) m long and 10–15 mm in diameter (up to 25 mm with sheaths), leaflets conspicuously rounded, and inflorescence with velvet-like covering. It is distributed from Gabon to Cabinda (Angola). The whole stem is used for making furniture frames and bridges, and in house construction, the split stem is used for making temporary market baskets and other woven products, and the base of the leaf sheath serves as a toothbrush. In Congo a soup of the terminal buds is eaten against worms, and plant sap is dropped in the ear for the treatment of otitis.

Eremospatha cuspidata (G.Mann & H.Wendl.) G.Mann & H.Wendl. is a relatively rare, slender rattan with stems 12–15 m long and 10–15 mm in diameter (16–25 mm with sheaths), and leaflets with a conspicuously apiculate apex. It is distributed from Cameroon and the Central African Republic southwards to Zambia and Angola. The split stems are used for light basketry and weaving.

Eremospatha haullevilleana De Wild. is a slender to moderately robust rattan with stems up to 25 m long and 6–15 mm in diameter (10–25 mm with sheaths), leaf sheath conspicuously striate, and leaflets highly variable. It is distributed from Cameroon and the Central African Republic southwards to DR Congo, Tanzania and Angola. The whole stems are used for a range of products, including furniture framework, building frames, traps, walking sticks, rope and cables for cane bridges. The split stems are used for fish traps, chairs, basketry, rope, string, snares and handrails of bridges. Bark strips are used for furniture and wickerwork. The softened stem is used as a toothbrush, and the leaves are used for thatching. The apical bud (palm heart) is widely eaten. In DR Congo the acanthophylls are used as fish hooks and the fruits are used for decoration, especially in traditional collars. In Gabon unspecified parts are locally used against worms.

Eremospatha hookeri (G.Mann & H.Wendl.) H.Wendl. is a relatively slender rattan with stems up to 30 m long and 15–20 mm in diameter (20–30 mm with sheaths), and ovate-oblanceolate leaflets. It is distributed from

Nigeria to Gabon, DR Congo and Cabinda (Angola). The split stem is used as a strong tying material, and the base of the leaf sheath serves as a chewing stick.

Eremospatha laurentii De Wild. is a robust rattan with stems up to 30 m long and 18–25 mm in diameter (25–30 mm with sheaths), and linear basal leaflets. It is distributed from Sierra Leone to the Central African Republic and DR Congo, but absent from Côte d'Ivoire to Benin. The stem is of poor quality and is seldom used for furniture or basketry.

Eremospatha quinquecostulata Becc. is a slender rattan with stems 10–15 m long and 4–9 mm in diameter (5–10 mm with sheaths). It is restricted to south-eastern Nigeria and Cameroon. The split stem is used for weaving.

Eremospatha wendlandiana Dammer ex Becc. (synonym: *Eremospatha korthalsiaefolia* Becc.) is a robust rattan with stems up to 60 m long and 12–20 mm in diameter (15–30 mm with sheaths), ocrea characteristically tattering, and leaflets triangular and rhomboid. It is distributed from Nigeria eastwards to the Central African Republic and southwards to Cabinda (Angola). The stem is used for basketry, beds and chairs. The split stem is used for tying house frames before plastering with clay, the split epidermis of the stem is used for tying yams, and the base of the leaf sheath serves as a chewing stick. The roasted apex of young stems is eaten.

Anatomy The cross section of the stem shows three distinct regions: epidermis, cortex and central cylinder. The epidermis is comprised of a single layer of almost rectangular parenchyma cells 12.8–19.7 μm long and 8.7–12.8 μm wide. The cortex consists of fibre bands, rudimentary vascular bundles embedded in parenchyma cells, lying ring-like around the central cylinder. The cortex is 113–733 μm wide. The cortical cells are interconnected, round to oval in shape, with varying sizes; they are more lignified in the basal internodes than at the top. There are 2–3 fibre rows just below the epidermis. The central cylinder is composed of vascular bundles embedded in ground parenchyma. The vascular bundles consist of conducting tissue (xylem and phloem), surrounded by a fibre sheath and parenchyma. Per vascular bundle there are two metaxylem vessels 200–438 μm wide, the protoxylem consists of a cluster of 2–10 vessels, and the phloem consists of a single field with 4–12 sieve tubes. The surrounding fibre sheath is slightly broader in the peripheral and basal vascular bundles than in the inner and top ones. The fibre cells are 0.8–2.6 mm long and 8.7–40.6 μm wide, with a lumen width of 2.9–34.8 μm and a cell wall thickness of 2.9–31.9 μm. The ground parenchyma cells are round to oval in shape with varying sizes, they are more lignified in basal than in top internodes.

Growth and development All *Eremospatha* species are pleonanthic, i.e. the stems do not die after flowering. The seeds of most African rattans are dispersed primarily by birds (especially hornbills). However, primates, predominantly drills, mandrills, chimpanzees and gorillas are also key dispersal agents, as are elephants. Predation by rodents accounts for some additional dispersal.

Ecology *Eremospatha dransfieldii* is a light-demanding species preferring forest margins, forest gaps and roadsides. It is restricted to areas with an average annual rainfall over 2000 mm and is locally abundant.

Propagation and planting In Africa rattans are usually exploited from wild sources. In Ghana, Nigeria and Cameroon community-based trials concentrating on the introduction of rattans into agroforestry systems and enrichment planting of farm bush and secondary forest have been established but farmer adoption has remained low.

Management In Africa rattans are considered open-access resources, and there are very few, if any customary laws regulating the harvest of rattan from the wild. Where they exist, external commercial harvesters often pay a small sum to the Chief and Council of the local village for access to the forest. Most national forestry codes still do not include the exploitation of NTFPs in their regulations and thus for most commercially important products including rattans, over-harvesting is uncontrolled and unabated. In Ghana, where exploitation of NTFPs is supposed to be governed by licenses and permits, there are no adequate monitoring systems for the exploitation of these resources, nor are they subject to the full forestry taxes related to the exploitation of these resources. Where those who harvest the rattan have more defined resource tenure, younger stems are not removed and are left to regenerate to provide a future source of cane, usually on a two- to three-year rotation.

Diseases and pests The stems have very high starch and moisture contents, which render them highly susceptible to attacks by fungi and insects. Fungi cause discoloration of the canes, while beetles cause pinholes or worm holes. Defects resulting from infections by fungi and beetles can result in severe post-harvest losses.

Harvesting Rattan harvesting in Africa is undertaken manually using cutlasses or machetes. It is a very difficult activity, particularly when rattans become entangled with each other and in the canopies of adjacent trees. The spines on the leaves of *Eremospatha dransfieldii* may result in various forms of injury to collectors. Hence, more efficient and better methods of harvesting such as the use of simple but effective tools and wearing of protective clothing are necessary.

The choice of the method used for harvesting rattans from their clumps may influence the survival and growth of new stems as well as regeneration of cut stems. Sustainable harvesting means taking into consideration variables such as the number of mature stems that can be removed from a clump, the height at which to cut the cane from the ground, the harvesting cycle, the maturity of the stem, removal of entangled upper stems to create gaps and the length of the stem to be harvested.

Yield A good harvester can cut about 140 stems per day.

Handling after harvest Most harvesters air-dry the stems and apply limited prophylactic treatments to prevent or reduce the incidence of attacks by fungi and insects at harvesting sites and during transportation to processing sites.

Genetic resources Although *Eremospatha dransfieldii* is not included in the IUCN Red list, it is considered vulnerable due to its limited distribution and present overharvesting, especially in Ghana.

Prospects *Eremospatha dransfieldii* was described quite recently and has been somewhat under-studied. In general, there is growing interest in the rattans of Africa owing to their importance in the livelihoods of rural as well as urban traders and artisans. Research on rattans in Ghana, Nigeria and Cameroon has shown that cultivation is ecologically feasible, but hampered by socio-economic and socio-cultural factors such as land tenure and perceptions of unlimited wild supplies.

Major references Ebanyenle & Oteng-Amoako, 2003; Hawthorne & Jongkind, 2006; Oteng-Amoako & Obiri-Darko, 2002; Sunderland, 2003; Sunderland, 2007; Sunderland et al., 2005; Sunderland et al., 2008; Uhl & Dransfield, 1987.

Other references Abbiw, 1990; Ebanyenle & Oteng-Amoako, 2005; Kawukpa & Angoyo, 1994; Morakinyo, 1995a; Neuwinger, 2000; Oteng-Amoako & Ebanyenle, 2002; Raponda-Walker & Sillans, 1961; Sunderland, 1998a; Sunderland, 2001a; Sunderland, 2002a; Sunderland, 2002b; Sunderland, Balinga & Groves, 2002; Tanno, 1981; Terashima & Ichikawa, 2003; Terashima, Kalala & Malasi, 1991; Townson, 1995.

Sources of illustration Sunderland et al., 2005.

Authors E. Opuni-Frimpong, S. Acheampong Owusu, E. Ebanyenle & T.C.H. Sunderland

EREMOSPATHA MACROCARPA (G.Mann & H.Wendl.) H.Wendl.

Protologue Les Palmiers: 244 (1878).

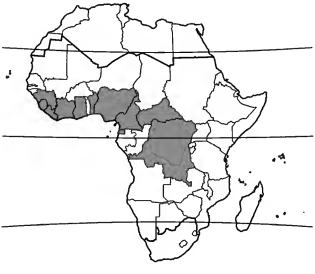
Family Arecaceae (Palmae)

Synonyms *Calamus macrocarpus* G.Mann & H.Wendl. (1864), *Eremospatha sapini* De Wild. (1916).

Vernacular names Small rattan palm, large-fruit rattan palm (En).

Origin and geographic distribution *Eremospatha macrocarpa* is distributed from Sierra Leone to the Central African Republic and DR Congo.

Uses The whole stems are ideal for building cane bridges due to their flexibility. They are also used for binding in house construction and for making furniture. In Ghana they are woven into screens for fencing. The split stems are used for making baskets and mats. The bark is easily peeled off and provides strong cordage. The leaves are used for thatching. Potential uses of the stem include the production of par-



Eremospatha macrocarpa – wild

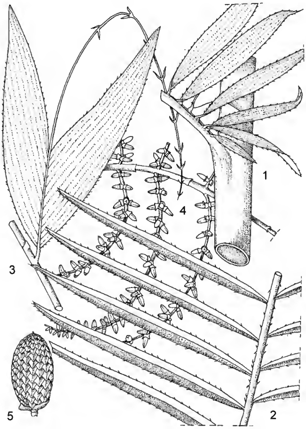
ticle board and briquettes from waste material from furniture making. In traditional medicine in Ghana and Nigeria the powdered root is taken for the treatment of syphilis.

Production and international trade The cane of *Eremospatha macrocarpa* is widely traded and one of the favoured commercial rattans in West and Central Africa. However, very limited information is available on rattan exports from African countries. It is known that Ghana supplied a significant proportion of the canes in the United Kingdom market during the period between the two World Wars. There have also been reports of export of raw cane from Ghana and Nigeria to South-East Asia, and of a flourishing export trade from Nigeria to Korea. The local trade forms a significant part of the local economy in both rural and urban communities, with many people involved in the rattan industry. In Ghana, for instance, the rattan industry is estimated to contribute about 20% of the total revenue from the trade in non-timber forest products (NTFPs). However, many processors have complaints about the low price they get for finished products. For example, 50% of weavers in Ghana mentioned the low price of and irregular demand for finished products as the most important constraints in the marketing of rattan products. In urban areas products are rarely sold from formal display centres but mostly in informal stalls along roads. The amount of rattan canes supplied to urban markets in West and Central Africa has been estimated at a total length of 340,000 m per month. The unit of trade of commercial rattans is the 'packet', which, for small-diameter canes such as *Eremospatha macrocarpa*, comprises 20 stems 5 m long.

Properties *Eremospatha macrocarpa* is the best source of cane in Africa. The stems are flexible and of comparable quality to the small-diameter rattans of South-East Asia. The stem is reddish brown and light to medium weight, with a density of 440–560 kg/m^3 when oven-dry. At 12% moisture content stems from Nigeria had a modulus of rupture of 11 N/mm^2 and a modulus of elasticity of 520 N/mm^2. The stems are fairly durable but susceptible to attacks by termites. Air-dried samples of the stems in Nigeria were recorded to contain per 100 g: water 16.2 g, energy 1336 kJ (319 kcal), protein 3.9 g, fat 0.5 g, carbohydrate 77.9 g, ash 1.6 g, Ca 187 mg, Mg 39 mg.

Adulterations and substitutes *Calamus deërratus* G.Mann & H.Wendl., a species considered to be of inferior quality is sometimes utilized in the absence of *Eremospatha macrocarpa*.

Description Slender to moderately robust rattan palm, growing in clumps; stem up to 50–75(–150) m long, 8–19 mm in diameter without sheaths, 22–30 mm in diameter with sheaths, internodes 20–33 cm long. Leaves up to 3.5 m long, pinnately compound with up to 25 leaflets on each side of the rachis; sheath longitudinally striate, unarmed; ocrea entire, saddle-shaped, with rounded lobe 2.5–4 cm long; petiole short in leaves of juvenile palms, absent in older ones; rachis 1–1.5 m long, unarmed, distally prolonged into cirrus up to 2 m long bearing acanthophylls (leaflets modified into reflexed hooks) c. 3 cm long; leaflets of juvenile palms sharply bifid, leaflets of adult ones linear to lanceolate, generally drooping, 22–35 cm × 2–2.5 cm, narrowly praemorse at the apex, with sharp teeth on the margins and pointed ends. Inflorescence axillary, up to 55 cm long, arching outwards, branched to 1 order; rachis 25–40 cm long; branches horizontal; peduncle



Eremospatha macrocarpa – 1, part of stem; 2, part of leaf; 3, leaf of juvenile plant; 4, part of inflorescence; 5, fruit.
Redrawn and adapted by Achmad Satiri Nurhaman

10–15 cm long. Flowers in pairs, bisexual, sessile, buff yellow, very fragrant; calyx c. 3 mm long, thick, leathery, shallowly 3-lobed; corolla c. 10 mm long, thick, leathery, with 3 valvate lobes; stamens 6, united into a ring; gynoecium 3-carpellate. Fruit cylindrical to oblong-ellipsoid, 2–3 cm × 1–1.5 cm, pale orange to brown, with 15–24 rows of scales, 1(–2)-seeded. Seeds compressed, c. 2 cm × 1.5 cm × 1 cm.

Other botanical information *Eremospatha* is one of the three rattan genera endemic to Africa. It comprises 11 species, which are easily distinguished from each other on the basis of vegetative characteristics.

Anatomy The cross section of the stem shows three distinct regions: epidermis, cortex and central cylinder. The epidermis consists of a single layer of almost square parenchyma cells 9.9–16.8 μm long and 9–13.3 μm wide. The cortex consists of fibre bands (rudimentary vascular bundles) embedded in parenchyma cells, lying ring-like around the central cylinder. The cortex is 73–373 μm wide. The cortical cells are interconnected, round to oval in shape, with varying sizes; they are more lignified in the basal internodes than at the top. There are 2–3 fibre rows just below the epidermis. The central cylinder is composed of vascular bundles embedded in ground parenchyma. The vascular bundles consist of conducting tissue (xylem and phloem), surrounded by a fibre sheath and parenchyma. Per vascular bundle there are two metaxylem vessels 150–440 μm wide, the protoxylem consists of a cluster of 2–10 vessels, and the phloem consists of a single field with 4–12 sieve tubes. The surrounding fibre sheath is slightly broader in the peripheral and basal vascular bundles than in the inner and top ones. The fibre cells are 0.2–2.6 mm long and 8.7–43.5 μm wide, with a lumen width of 1.5–37.7 μm and a cell wall thickness of 2.9–26.1 μm. The ground parenchyma cells are round to oval in shape with uniform sizes.

Growth and development *Eremospatha macrocarpa* has a long germination period and high initial seed mortality. In Cameroon an annual extension growth of 3.2 m has proven possible, making *Eremospatha macrocarpa* very suitable for short rotation agroforestry. All *Eremospatha* species are pleonanthic, i.e. the stems do not die after flowering. The seeds of most African rattans are dispersed primarily by birds (especially hornbills). However, primates, predominantly drills and mandrills (two species of forest primate related to the baboon), chimpanzees and gorillas are also key dispersal agents, as are elephants. Predation by rodents accounts for some additional dispersal.

Ecology *Eremospatha macrocarpa* occurs in forest margins, gaps and regrowth vegetation. It is extremely light-demanding and responds well to selective logging in the forest. The species is rare in swamp forest.

Propagation and planting In Africa rattans are usually exploited from wild sources, and there is little cultivation despite favourable ecological factors and growth rates that suggest cultivation would be feasible. This contrasts with the situation in South-East Asia, where traditional rattan cultivation practices exist such as the cultivation in mixed gardens by sedentary cultivators or in recently burned forests by shifting cultivators. In Ghana, Nigeria and Cameroon community-based trials concentrating on the introduction of rattans into agroforestry systems and enrichment planting of farm bush and secondary forest have been established but farmer adoption has remained low.

Propagation by seed is possible, but germination is slow and seed mortality high. Trials in Cameroon showed germination rates of 32.5%, with a time to first emergence of 96 days. In nursery trials with suckers in Côte d'Ivoire shoots emerged 43–93 days after planting.

In on-farm trials in Ghana, Nigeria and Cameroon a high post-planting mortality was recorded, which is attributed to neglect and predation by rodents.

Management In Africa rattans are considered open-access resources, and there are very few, if any customary laws regulating exploitation of wild rattan. Where they exist, external commercial harvesters often pay a small sum to the Chief and Council of the local village for access to the forest. Most national forestry codes still do not include the exploitation of NTFPs in their regulations and thus for most commercially important products including rattans, over-harvesting is uncontrolled and unabated. In Ghana, where exploitation of NTFPs is supposed to be governed by licenses and permits, there are no adequate monitoring systems for the exploitation of these resources, nor are they subject to the full forestry taxes related to the exploitation of these resources. Where those who harvest the rattan have more defined resource tenure, younger stems are not removed and are left to regenerate to provide a future source of cane, usually on a two- to three-year rotation.

Diseases and pests The stems have very high starch and moisture contents, which render them highly susceptible to attacks by fungi and insects. Fungi cause discoloration of the canes, while beetles cause pinholes or worm holes. Defects resulting from infections by fungi and beetles can result in severe post-harvest losses.

Seedlings of *Eremospatha macrocarpa* are eaten by rodents.

Harvesting Rattans are harvested manually, which can be difficult activity, particularly when rattans become entangled with each other and in the canopies of adjacent trees. The leaves of *Eremospatha macrocarpa* have thorns which may result in various forms of injury to collectors, and better and more efficient methods of harvesting such as the use of simple but effective tools and wearing of adequate protective clothing are called for. The choice of the method used for harvesting rattans from their clumps may influence the survival and growth of new stems as well as regeneration of cut stems. Sustainable harvesting means taking into consideration variables such as the number of mature stems that can be removed from a clump, the height at which to cut the cane from the ground, the harvesting cycle, the maturity of the stem, removal of entangled upper stems to create gaps and the length of the stem to be harvested.

Handling after harvest After the extraction of the stems from the forest, they are bundled in packets to be sold. Processing of the raw cane involves removing the epidermis (skin) from the stem and drying the raw cane. In much of Africa this is done manually by scraping the stem with a kitchen knife to remove the skin and then drying the raw cane, which is usually done in the open with little or no preservative treatment. Transportation from the forest to the roadsides or villages is usually by head-portering, which influences the price of cane and cane products, as nowadays harvesters have to travel long distances to harvest the canes.

Genetic resources *Eremospatha macrocarpa* is widespread and locally common throughout its range. It is not considered threatened according to IUCN criteria, but populations easily accessible to harvesters are under great pressure which could lead to a loss of entire populations, thus eroding the genetic base.

Prospects *Eremospatha macrocarpa* will remain one of the most desired rattans of Africa. Surprisingly little information is available on the species, and research is needed to assess its potential for cultivation, although initial research has shown that issues such as land tenure and the relative abundance of rattans in the wild keep adoption of cultivation by farmers low. There are also prospects for better processing of the raw cane to produce high quality products of international standards that are able to compete on the global market. Sustainable management of the species can help in poverty alleviation in the rural and urban communities involved in the harvest and manufacture of rattan products.

Major references Abbiw, 1990; Burkill, 1997; Ebanyenle & Oteng-Amoako, 2003; Falconer, 1994; Hall & Swaine, 1981; Hawthorne & Jongkind, 2006; Sunderland, 2001b; Sunderland, 2007; Sunderland et al., 2005; Sunderland et al., 2008.

Other references Ebanyenle & Oteng-Amoako, 2005; Irvine, 1952; Irvine, 1961; Kouakou et al., 2009a; Kyei, 2004; Lucas & Dahunsi, 2004; Morakinyo, 1995a; Olorunnisola, 2004; Osei, 2005; Oteng-Amoako & Ebanyenle, 2002; Oteng-Amoako & Obiri-Darko, 2002; Otoo, 2001; Quarcoo, 1996; Sunderland, 1998a; Sunderland, 2001a; Sunderland, 2002a; Sunderland, 2003; Sunderland, Balinga & Groves, 2002; Townson, 1995; Uhl & Dransfield, 1987.

Sources of illustration Sunderland, 2001b.

Authors E. Opuni-Frimpong, S. Acheampong Owusu, E. Ebanyenle & T.C.H. Sunderland

ERICA SIMII (S.Moore) E.G.H.Oliv.

Protologue S. African J. Bot. 53(6): 457 (1987).

Family Ericaceae

Synonyms *Philippia simii* S.Moore (1911), *Philippia friesii* Weim. (1940).

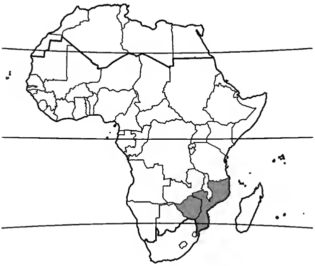
Vernacular names Transvaal tree philippia, false Transvaal tree heath, white-velvet philippia (En). Vassoura (Po).

Origin and geographic distribution *Erica simii* occurs in the Beira area of Mozambique, in neighbouring parts of Zimbabwe, and in a small area in South Africa (Limpopo).

Uses The branches are used as brooms.

Production and international trade *Erica simii* is only used and traded locally.

Botany Shrub or small tree up to 5 m tall; branchlets ridged between nodes, densely covered with very short hairs. Leaves in whorls of 3, ascending and often slightly curved out-



Erica simii – wild

wards, simple; petiole c. 0.5 mm long, with very short hairs on the margins; blade linear to narrowly ovate, 1–5 mm × c. 0.5 mm, obtuse, with glands and minute hairs on the margins, otherwise glabrous. Inflorescence a cluster of normally 3, sometimes 6 flowers, at the tips of branchlets. Flowers bisexual; pedicel glabrous, expanded above, 1.5–2.5 mm long; calyx and corolla normally 4-partite, occasionally 3-partite in some flowers; calyx funnel-shaped, ciliate at the margins, otherwise glabrous, with 4 lobes; 3 lobes equal, fused for about ¼ their length, triangular, 1.5–2 mm long, usually exceeding the sinus between the corolla lobes, leaf-like at the tips, acute, the 4th lobe usually slightly longer, sometimes much longer and exceeding the corolla; corolla bell-shaped, yellowish green and crimson, 1.5–2.5 mm long, lobes broadly rounded, sinuses narrowly rounded; stamens 8, equalling the corolla, becoming free shortly after anthesis; ovary glabrous, 4-celled, style broadly conical, c. 1.5 mm long, shortly exserted in flower, more strongly exserted beyond the persistent corolla in fruit. Fruit a 4-celled capsule contained within the persistent calyx and corolla; cells 1-seeded.

Erica is a genus of c. 600 species, mostly in the Cape region of South Africa, but extending into tropical Africa (usually above 1000 m altitude) and northwards into Europe.

Ecology *Erica simii* occurs from sea-level up to 2600 m altitude in open woodland and savanna or scattered in montane grassland, on damp sands near the coast and inland often on rocky slopes beside streams or rivers. It occurs in small, dense stands.

Management *Erica simii* is only collected from the wild.

Genetic resources and breeding *Erica simii* has a rather small area of distribution. It is not known if it is in danger of genetic erosion. In the Zimbabwe Red list it is classified as data deficient.

Prospects *Erica simii* will probably remain of occasional local use only.

Major references Oliver, 1987; Ross, 1983; van Wyk & Gericke, 2000.

Other references Coates Palgrave, 1983; Oliver, 1992.

Authors L.P.A. Oyen

EUCALYPTUS ALBA Reinw. ex Blume

Protologue Bijdr. Fl. Ned. Ind. 17: 1101 (1827).

Family Myrtaceae

Chromosome number $2n = 22$

Synonyms *Eucalyptus leucadendron* Reinw. ex. de Vriese (1856).

Vernacular names White gum, poplar gum, khaki gum, Timor white gum (En).

Origin and geographic distribution *Eucalyptus alba* is native to northern Australia, Papua New Guinea and Timor, and has been planted throughout the tropics. Its present distribution in tropical Africa is unclear, particularly because *Eucalyptus alba* hybridizes readily with other *Eucalyptus* species. In Congo, for instance, hybrids of *Eucalyptus alba* and other *Eucalyptus* species have been widely used in reforestation. Eucalypts introduced as *Eucalyptus alba* into Brazil around 1920 in fact belonged to *Eucalyptus urophylla* S.T.Blake. Large stands of descendants of these trees still exist in Brazil, and are still referred to as *Eucalyptus alba*. As genuine *Eucalyptus alba* is also grown in Brazil, there is much confusion.

Uses *Eucalyptus alba* is mainly used for paper making. The timber is used for light and heavy construction, flooring, mine timber, boat building, furniture, handles, sporting goods, agricultural implements, joinery, railway sleepers, poles and carvings. The wood is often used as fuelwood and for making charcoal. *Eucalyptus alba* is a bee forage and is used in reforestation programmes and in swampy areas for reclamation purposes. It is also planted as an ornamental tree.

Properties *Eucalyptus alba* wood from India contained 60.3% holocellulose (including 14.1% pentosan), 27.9% lignin and 0.4% ash. The fibre cells were on average 0.88 mm long and

19.2 μm wide, with a cell wall thickness of 4.8 μm and a lumen width of 9.8 μm. Pulping with the kraft process yielded 49% pulp with good strength properties and low kappa number.

The sapwood is pale reddish brown, the heartwood is darker. The density of the wood is 900–1010 kg/m^3 at 12% moisture content. The rates of shrinkage from green to 12% moisture content are 2.9% radial and 4.6% tangential. The wood is moderately strong and hard. The durability ranges from poor to good, depending on provenance and location. The bark contains 30–32% tannins.

Air-dried leaves from Burkina Faso yielded 1.2% oil, with as main compounds β-pinene (31.0%), α-pinene (20.1%), limonene (16.8%), β-caryophyllene (6.6%), γ-terpinene (5.6%), p-cymene (3.2%), α-terpineol (3.1%) and bicyclogermacrene (2.0%). Fresh leaves from Nigeria yielded 0.28% essential oil. The major compounds were α-thujene (32.9%), 1,8-cineole (13.3%), p-cymene (12.9%), β-caryophyllene (7.8%), α-terpineol (2.6%), spathulenol (2.2%) and caryophyllenoxide (1.9%). The oil showed activity against the bacteria *Escherichia coli* and *Pseudomonas aeruginosa*, but not against the bacteria *Bacillus cereus* and *Staphylococcus aureus* and the fungus *Candida albicans*. Fresh leaves from DR Congo yielded 0.22% essential oil, with as main compounds β-pinene (25.3%), β-terpineol (13.6%), p-cymene (7.4%), α-terpineol (6.2%), 1,8-cineole (5.2%), limonene (4.6%), β-eudesmol (4.6%), α-pinene (4.3%), β-caryophyllene (4.3%) and spathulenol (4.1%). This oil showed activity against a range of bacteria and fungi.

Botany More or less deciduous, small to large tree up to 25(–40) m tall; bole often of poor form, up to 60(–80) cm in diameter; bark smooth, pink-red to white or cream, surface covered with powdery bloom, exfoliating. Leaves alternate, simple and entire; stipules absent; petiole flattened or angular, 10–33 mm long; blade lanceolate or ovate, 7–21 cm × 2–5 cm, acuminate at apex, thin, green, concolorous, lateral veins conspicuous. Inflorescence axillary, simple; umbels 3–7-flowered; peduncle terete or angular, up to 2 cm long. Flowers bisexual, regular; pedicel absent or angular, up to 7 mm long; flower buds globular to ovoid, 8–9 mm long, divided into a hemispherical hypanthium (lower part), 3–5 mm × 4–7 mm, and a hemispherical operculum (upper part), 3–5 mm × 4–7 mm, which is shed at anthesis; stamens numerous; ovary inferior. Fruit a hemispherical to obconical capsule 4–7 mm × 5–8 mm, opening with 3–4 exserted valves, many-seeded. Seedling with epigeal germination.

On good sites an annual height growth of 3 m is possible during the first years. In Vietnam, for instance, trees in 5-year-old stands were 15 m tall, with an average bole diameter of 17 cm. In trials in Madagascar (Mangoro area, altitude 950 m, average annual rainfall 1200 mm), however, 10-year-old *Eucalyptus alba* trees, planted at 3 m × 3 m, were only 6.6 m tall, with a basal area of 72 cm^2 and a total wood production of 33 m^3/ha.

Eucalyptus comprises about 800 species, endemic to Australia, except for about 10 species in the eastern part of South-East Asia. Many *Eucalyptus* species are cultivated outside their natural distribution area, in tropical, subtropical and temperate regions, because of their rapid growth and adaptation to a wide range of ecological conditions. *Eucalyptus* is divided into several subgenera (7–10, depending on the author), which are subdivided into many sections and series. The results of phylogenetic studies within *Eucalyptus* suggest that the genus is polyphyletic, hence not of a single evolutionary origin, and consequently it has been proposed to divide the genus into several distinct genera. This has not yet been done, mainly because of the nomenclatural whirlpool this would bring about. *Eucalyptus* species hybridize easily, which adds to the taxonomic complexity.

Around Pointe Noire (Congo) large areas have been planted with clones of the hybrid E. PF1 (clones 1–41), which resulted from natural crosses between 2 or 3 individuals of *Eucalyptus alba* (mother tree) and a group of poorly identified hybrids from Brazil (father tree). The average productivity of 7-year-old plantations of this hybrid in Congo was 20 m^3/ha/year.

Ecology *Eucalyptus alba* is well adapted to dry lowland climates. It grows in areas with an average annual rainfall of (600–)750–2000(–2500) mm, with a dry period of (2–)4–8 months, and a mean annual temperature of 21–30°C, a mean temperature of the warmest month of 32–35°C, and a mean temperature of the coldest month of 5–10°C. It is fairly tolerant of flooding. In its native area *Eucalyptus alba* grows in flat and undulating country, often near the coast or near watercourses, on heavy soil in woodland and open forest from sea level to 700 m altitude.

Management *Eucalyptus alba* is easily propagated by seed. The 1000-seed weight is 1.1–3.7 g. One gram of dry seeds produces 100–

250 seedlings. Grafting is easy, but propagation by cuttings gives more problems. For pulpwood a spacing of 3 m × 2 m is common. *Eucalyptus alba* has a good coppicing ability. The main diseases in *Eucalyptus alba* plantations, particularly in Brazil, are caused by *Cylindrocladium* fungi. In Brazil rotations of 5–7 years are used for pulpwood production, and rotations of 15–30 year for timber. On sandy and clayey savanna soils in the Congo basin mean annual volume increments of 6–10 m³/ha have been recorded.

Genetic resources and breeding Substantial genetic variation is present within *Eucalyptus alba*, and careful progeny testing should be carried out when it is considered for planting.

Prospects *Eucalyptus alba* is a useful source of pulpwood, timber and fuel in the dry lowland tropics. Its distribution, importance and prospects for tropical Africa are difficult to assess, especially because it hybridizes readily with other *Eucalyptus* species.

Major references CAB International, 2010c; Dutt & Tyagi, 2011; Jacobs, 1981; Lamb et al., 1993; Lamprecht, 1989.

Other references Chen & Craven, 2007; Chippendale, 1988; Cimanga et al., 2002a; Cimanga et al., 2002b; Delwaulle, 1979; Laclau, Bouillet & Ranger, 2000; Lebot & Ranaivoson, 1994; Oyedeji et al., 1999a; Oyedeji et al., 1999b; Samaté et al., 1998.

Authors S. Masila

EUCALYPTUS DEGLUPTA Blume

Protologue Mus. Bot. 1(6): 83 (1850).

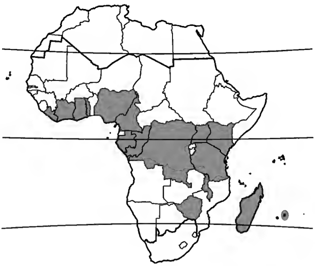
Family Myrtaceae

Chromosome number $2n = 22$

Synonyms *Eucalyptus multiflora* Rich. ex A.Gray (1854), *Eucalyptus naudiniana* F.Muell. (1886), *Eucalyptus schlechteri* Diels (1922).

Vernacular names Mindanao gum, deglupta, rainbow eucalyptus, rainbow bark, rainbow gum (En). Eucalyptus arc-en-ciel, gommier arc-en-ciel, gommier de Mindanao (Fr). Goma de Mindanao, goma do arco-íris (Po).

Origin and geographic distribution *Eucalyptus deglupta* has a natural distribution from Sulawesi (Indonesia) and Mindanao (Philippines) eastward to New Britain (Papua New Guinea). It is one of the few *Eucalyptus* species not occurring in Australia. It is widely planted throughout the humid tropics, where it is one of the most important eucalypts.



Eucalyptus deglupta – planted

Uses *Eucalyptus deglupta* is a major plantation tree for pulp production; both the wood and bark are good sources of pulp. The wood is valuable timber (trade name: kamarere), suitable for light and heavy construction, flooring, furniture, joinery, moulding, boat building, posts, poles, veneer, plywood, particle board, hardboard and wood-wool board. It is also used as fuelwood and for charcoal making, but is normally considered too valuable for these purposes. *Eucalyptus deglupta* is widely planted as an ornamental tree because of its attractive bark. The tree is used for land reclamation, reforestation and forest enrichment planting. In Costa Rica it is commonly used as a shade tree in coffee plantations. It is a bee forage.

Production and international trade In the 1990s the area planted with *Eucalyptus deglupta* was about 30,000 ha in Indonesia and the Philippines each, and about 10,000 ha in Brazil. Other countries with substantial plantations were Malaysia, Papua New Guinea, Sri Lanka, Fiji, Côte d'Ivoire and Ghana.

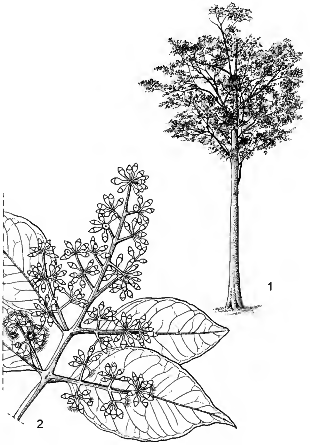
Properties The wood contains 44–51% cellulose, 29–30% lignin, 14–19% pentosan and 0.6–1.2% ash. The ultimate fibres in wood from Côte d'Ivoire are on average 1.0 mm long and 19.5 μm wide, with a lumen width of 12 μm. Pulping with the kraft (sulphate) process gives a strong pulp which can be bleached to a good brightness.

The heartwood is reddish brown, not always distinctly demarcated from the whitish to pink sapwood. The grain is interlocked, texture moderately coarse. The wood has a ribbon-like aspect on quarter-sawn faces, and is lustrous.

The density of the wood is 390–810 kg/m³ at 15% moisture content, but young wood is lighter than older wood, and wood from plantations is lighter than that from natural forest. Plantation wood is easy to dry, with little degrade, but forest wood may collapse. The rates of shrinkage from green to 12% moisture content are 1.8–2.4% radial and 3.4–7.0% tangential. At 12% moisture content, the modulus of rupture is 67–106 N/mm², modulus of elasticity 8000–14,075 N/mm², compression parallel to grain 39–70 N/mm² and shear 7–11 N/mm². The wood works well with hand and machine tools, but it has a slight tendency to tear out in machining and boring and to slight chipping of sharp edges in turning. It finishes well. The wood is not durable; it is liable to termite and *Lyctus* attack (particularly sapwood), and also to marine borers. Plantation grown wood is significantly easier to impregnate than wood from natural forest. The energy value of the wood is 18,500–21,100 kJ/kg.

Fresh leaves from Nigeria yielded 0.2% essential oil. The major compounds were nerolidol (34.8%), α-pinene (24.7%), β-caryophyllene (5.9%), limonene (4.1%), α-terpineol (4.1%) and p-cymene (3.1%). Fresh leaves from DR Congo yielded 0.15% essential oil, with as main compounds 1,8-cineole (35.7%), cryptone (25.4%), myrtenol (7.4%), β-terpineol (6.3%) and globulol (3.1%). The essential oil has shown activity against a range of bacteria and fungi. The oil content is too low for commercial exploitation.

Description Evergreen, very large tree up to 60(–80) m tall; bole generally of good form, 50–75% of the tree height, up to 200(–300) cm in diameter, sometimes with buttresses 3–4 m high; bark smooth, yellow, brown and purple, but green after flaking; crown conical in young trees, spreading in older ones; twigs 4-sided, often with 4 longitudinal wings. Leaves opposite, subopposite or alternate, simple and entire, held almost horizontal on branches; stipules absent; petiole 1–1.5 cm long; blade ovate to ovate-lanceolate, 7–15(–20) cm × 4–7.5(–10) cm, apex rounded to acute or slightly acuminate, glabrous, lower surface paler than upper surface, pinnately veined. Inflorescence an axial or terminal, condensed and reduced, umbel-like dichasium ('conflorescence'), umbels 3–7-flowered; peduncle up to 12 mm long, angular. Flowers bisexual, regular; pedicel c. 5 mm long; flower buds globular to nearly club-shaped, 2–4 mm × 2–5 mm, apiculate, divided into a conical hypanthium (lower part) 2–2.5 mm long, and a hemispherical or conical operculum (upper part) shed at anthesis; stamens numerous; ovary inferior. Fruit a thin-walled, ovoid to club-shaped or globose capsule 3–5 mm × 3–5 mm, enclosed in a woody hypanthium, opening with 3–4 small, exserted valves, many-seeded. Seeds minute, brown, flattened, with a small terminal wing. Seedling with epigeal germination.



Eucalyptus deglupta – 1, tree habit; 2, flowering twig.
Source: PROSEA

Other botanical information *Eucalyptus* comprises about 800 species, endemic to Australia, except for about 10 species in the eastern part of South-East Asia. Many *Eucalyptus* species are cultivated outside their natural distribution area, in tropical, subtropical and temperate regions, because of their rapid growth and adaptation to a wide range of ecological conditions. *Eucalyptus* is divided into several subgenera (7–10, depending on the author), which are subdivided into many sections and series. The results of phylogenetic studies within *Eucalyptus* suggest that the genus is polyphyletic, hence not of a single evolutionary origin, and consequently it has been proposed to divide the genus into several distinct genera. This has not yet been done, mainly because of the nomenclatural whirlpool this would bring about. *Eucalyptus* species hybridize easily, which adds to the taxonomic complexity.

Growth and development *Eucalyptus deglupta* grows very fast, being capable of annual growth rates of 2–3 m in height and 2–3 cm in diameter during the first 10 years. In Congo, for instance, trees 8.5 years old were on average 20 m tall, with a diameter of 13.5 cm. Shoot growth of young *Eucalyptus deglupta* appears to be continuous, provided soil moisture is adequate. Young trees have a conical crown with a definite leader and almost horizontal branches. As the tree ages, branches curve up at the ends and the leader becomes less dominant. In time the tree acquires a spreading, flat topped crown.

Flowering may occur within the first year but more often it takes place after 2 years and annually thereafter. Flowering can occur in all months of the year depending on locality. Fruiting may start as early as 1.5 years after planting, but more commonly after 3–4 years. Fruits ripen in 4–6 month, after which seeds are released rapidly over a few days. Seed production is often profuse. Dispersal is mainly by water. *Eucalyptus deglupta* does not regenerate from lignotubers. This means that mature trees are sensitive to intense fires, and that coppice harvests are usually not possible after the first harvest.

Ecology *Eucalyptus deglupta* is the only *Eucalyptus* species adapted to lowland and lower montane rain-forest habitats. It grows from sea-level up to 2500 m altitude in areas with a mean annual temperature of 20–32°C, a mean maximum temperature of the warmest month of 24–33°C, and a mean minimum temperature of the coldest month of 16–26°C, an evenly distributed average annual rainfall of (1200–)2000–5000 mm, and a dry season of 0–1 months. *Eucalyptus deglupta* may grow in cooler environments but does not tolerate frost. It requires full overhead light for development and dense stands are commonly found along rivers where it has colonized newly formed sand banks. *Eucalyptus deglupta* is also found on sites that have been cleared or disturbed in some way, e.g. by landslides, volcanic eruptions, or shifting cultivation. It is a rapid colonizer of such sites. In time, however, other species colonize and form a dense understorey which prevents subsequent regeneration of *Eucalyptus deglupta*. *Eucalyptus deglupta* prefers non-stagnant river flats with adequate soil moisture and grows best on deep, moderately fertile sandy loams but also on volcanic ash, pumice and gravel soils. In Congo it is recorded to grow better on heavy clay soils than on sandy soils. The species does not withstand prolonged flooding, however. It is highly sensitive to fire, due to its very thin bark.

Propagation and planting *Eucalyptus deglupta* is easily propagated from seed. The 1000-seed weight is 0.1–0.5 g. Seed can be obtained by collecting the fruits when they are greenish brown and drying them in the sun for 2–3 days. Seed can be stored 1–2 years under cool, dry and airtight conditions. The optimum temperature for germination is 32–35°C, and no pre-treatment is necessary. The seeds have a germination rate of 50–60% and one gram of dry seeds produces 1000–2000 seedlings. Germination takes 4–20 days and seedlings in nurseries can be planted out when they are 3–4 months old and 25–30 cm tall. In Gabon seedlings are planted at spacings of 4 m × 3 m on clay soils, and 4 m × 4 m on sandy soils. In pulpwood plantations in Congo a spacing of 2.8 m × 2.8 m is used.

Vegetative propagation with branch cuttings is easier than with other *Eucalyptus* species, and even cuttings from crowns of old trees can be used. The cuttings will root when their base is immersed in water alone. Plants 25–30 cm tall normally develop from cuttings within 6 weeks in tropical environments. Methods of in-vitro propagation have also been developed.

Management After seedlings have been planted out in Gabon, weed control measures are needed until the plants are about 2 years old and the crowns have closed. Plantations for sawlogs require thinning. *Eucalyptus deglupta* does not coppice well after cutting and must be replanted.

Diseases and pests Seedlings in nurseries are susceptible to damping-off caused by *Rhizoctonia solani*, which can be controlled by sterilization of the germination medium or application of fungicides. *Eucalyptus deglupta* is hardly attacked by leaf spot diseases, making it very suitable for the lowland tropics. Heart rot is sometimes found in older trees but is unlikely to be a problem in trees grown on a short (e.g. 10 years) rotation. Field observations suggest that heart rot is more common in trees growing on less well drained sites. Both in natural stands and in plantations termites are the most serious pest.

Harvesting Trees in pulpwood plantations are usually harvested 5–7(–12) years after planting, while plantations for sawlogs are harvested when they are 16–25 years old. Buttresses are frequent on trees growing on river alluviums and non stable soils in the natural area of distribution of the species; to harvest the logs, scaffolding has to be built so the stem can be sawn through above the buttresses.

Yield *Eucalyptus deglupta* is one of the fastest growing hardwood trees in the world. In pulpwood plantations yields of 200–300 m^3/ha at 10–12 years of age are commonly achieved. In plantations in Gabon the target bole diameter of 30 cm is attained when the trees are 8–10 years old, with a standing volume of 300–350 m^3/ha.

Genetic resources Provenance trials in Papua New Guinea using seed collected across the whole natural distribution range of *Eucalyptus deglupta* show variability in morphology, growth, and susceptibility to pests. Mindanao, Sulawesi and New Britain provenances appear to be better than the mainland Papua New Guinea ones. The trials included most of the mainland Papua New Guinea provenances of *Eucalyptus deglupta* but not many from Indonesia or the Philippines. In view of the variability already evident, it is highly desirable that the remaining provenances be tested as soon as possible, especially as some may be threatened by clearing for agriculture. The viability of seed material stored at −15°C is recorded to fall sharply after 7 years.

Breeding The variability within *Eucalyptus deglupta* offers potential for selection. Breeding work is in progress e.g. in Costa Rica and Indonesia.

Prospects *Eucalyptus deglupta* shows great promise for reforestation and afforestation in wet tropical lowland areas without a pronounced dry period. It has particularly high potential for industrial pulp production because of its easy vegetative propagation, rapid growth and excellent wood properties. Disadvantages of the species are its susceptibility to fire and the fact that it does not coppice well. Where heart rot and insect pests have been reported they appear to be only locally significant. Further, because of the genetic variability of *Eucalyptus deglupta* and the short delay till its reproductive period, there are good prospects for tree improvement.

Major references CAB International, 2010d; Chudnoff, 1980; Eldridge et al., 1993; Jacobs, 1981; Lamb et al., 1993; Lamprecht, 1989; Orwa et al., 2009; Scott, 1993; Webb et al., 1984.

Other references Bachir & Abdellah, 2006; Bégué, 1963; Cimanga et al., 2002a; Cimanga et al., 2002b; Coppen, 2002; Doat & Valette, 1980; FAO, 1974; Goudet, 1975; Goudet, 1980; Leakey et al., 1990; Nicolle, 2006; Oyedeji et al., 1999a; Oyedeji et al., 1999b; Raoufou, Kouami & Koffi, 2011; Schaller et al., 2003; van Oijen et al., 2010; Williams & Woinarski (Editors), 1997; Zech & Drechsel, 1992.

Sources of illustration Lamb et al., 1993.

Authors M. Brink

Based on PROSEA 5(1): Timber trees: Major commercial timbers.

EUCALYPTUS REGNANS F.Muell.

Protologue Rep. Acclim. Soc. Vict.: 20 (1870).

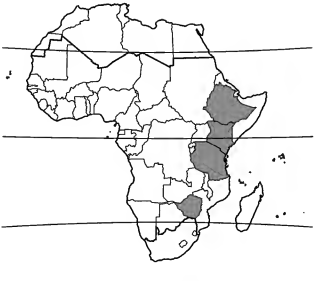
Family Myrtaceae

Chromosome number $2n = 22$

Vernacular names Mountain ash, Australian mountain ash, swamp gum, stringy gum, Victorian ash, white mountain ash (En).

Origin and geographic distribution *Eucalyptus regnans* is native to south-eastern Australia (Victoria and Tasmania), where it occurs in original forests and extensive plantations. It is widely planted in subtropical regions around the world and in the mid-altitude tropics, for instance in the United States, Chile, Spain, India and Sri Lanka. In New Zealand it is one of the primary plantation species. In Africa *Eucalyptus regnans* has been planted in Ethiopia, Kenya, Tanzania, Zimbabwe and South Africa.

Uses *Eucalyptus regnans* is the main *Eucalyptus* species used by the Australian pulp industry, and is a favoured pulpwood plantation species in southern Africa, New Zealand and



Eucalyptus regnans – planted

Argentina. The timber (trade name: Tasmanian oak) is used for a wide range of purposes, including light and heavy construction, flooring, boat building, joinery, interior trim, furniture, agricultural implements, tool handles, kitchen utensils, poles, crates, matches, turnery, veneer, plywood, fibreboard, particleboard and wood wool. It is also used as fuelwood and for charcoal making. Waste material (leaves, branches, bark) from *Eucalyptus regnans* plantations can be collected and used as fuel. Planted strips of *Eucalyptus regnans* can be used as windbreaks. Bees make honey from its nectar. An essential oil can be extracted from the leaves, but the yield is so low that the species has little value as an essential-oil-producing tree.

Production and international trade World-wide *Eucalyptus* plantations were estimated in 1995 at 14.6 million ha, of which 1.8 million ha were in Africa. Much of this was in South Africa. Very little of the world or African production of *Eucalyptus* wood and pulp comes from *Eucalyptus regnans*, but it is an important species in Tasmania and New Zealand.

Properties *Eucalyptus regnans* is considered one of the best *Eucalyptus* species with respect to pulp yield and quality, for all types of mechanical and chemical pulping processes. A study in Australia on the effect of tree age on pulp quality indicates that pulp quality improves up to 20–60 years and remains fairly constant thereafter. The wood fibre cells are 0.5–1.0 mm long and 18–280 μm wide. The chemical composition of the fibres is: cellulose 49%, hemicelluloses 15%, lignin 28% and ash 0.4%.

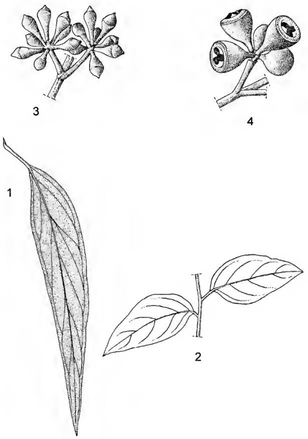
The heartwood is straw-coloured to pale reddish brown, and often not clearly differentiated from the paler, up to 2.5 cm wide sapwood. The grain is usually straight, texture coarse. Growth rings are often prominent. Quarter-sawn surfaces have an attractive figure. The density is 510–720 kg/m^3 at 12% moisture content, depending on age of the tree and growing conditions, with the wood of plantation-grown trees being less dense than that from natural stands. For instance, the density at 12% moisture content of wood from Australian natural forest is 650–720 kg/m^3, while that recorded for wood from African plantations is 510–570 kg/m^3. Due to the relatively low density of the wood, air-drying proceeds faster than in other *Eucalyptus* species, and the sapwood is easily treated with creosote or other chemical anti-rotting agents. The rates of shrinkage are high: from green to 12% moisture content 7% radial and 14% tangential. Common problems with the wood include growth tensions, and extreme shrinkage and collapse at drying, leading to bending and checking. Boards are usually quarter-sawn to reduce checking.

The wood is moderately strong, tough and hard. At 12% moisture content, the modulus of rupture is 110 N/mm^2, modulus of elasticity 16,000 N/mm^2 and compression parallel to grain 63 N/mm^2. The wood is easy to work, with only moderate blunting of tools. It saws cleanly and sharply and moulds well. Planing with the grain gives a very smooth surface. It drills easily and cleanly, and holds nails well, though pre-drilling is recommended. The wood takes stains and finishes well and glues satisfactorily. It is fairly bendable, and peels and slices satisfactorily. The durability of the wood is low, and it is not suitable for outdoor or ground-contact applications. The wood is liable to attacks by marine borers and termites. The sapwood is susceptible to attack by *Lyctus* borers, and therefore milled timber is usually sold without sapwood. The heartwood is resistant to impregnation with preservatives, the sapwood is permeable.

The wood has an energy value of 19,700 kJ/kg at 12% moisture content, and charcoal made from it has an energy value of 28,000 kJ/kg. The wood burns well and leaves little ash, while the charcoal burns almost without smoke. Conversion of wood to charcoal using traditional methods leads to a loss of more than two thirds of its embodied energy. In Spain the energy value of waste material (leaves, bark, and branches) can reach 65,000 MJ/ha per year.

The essential oil extracted from the leaves and branchlets of *Eucalyptus regnans* is markedly different from that of other *Eucalyptus* species, because it contains almost no cineole. It is mainly composed of α-phellandrene, and also contains p-cymene, eudesmols and small amounts of the ester geranyl-acetate.

Description Evergreen, very large tree up to 105 m tall; bole straight, up to 300 cm in diameter; bark rough and fibrous for the lower 15 m of the trunk, smooth and white or grey-green above, decorticating in long strips; crown open. Leaves alternate, simple and entire; stipules absent; petiole channelled, 8–25 mm long; blade lanceolate, 9–23 cm × 1.5–5 cm, slightly oblique or tapering at the base, acuminate at the apex, glossy, concolorous, green, venation oblique. Inflorescence a simple, um-



Eucalyptus regnans – 1, leaf of mature tree; 2, leaves of young tree; 3, flower buds; 4, dehisced fruits.
Redrawn and adapted by Achmad Satiri Nurhaman

bel-like dichasium, paired in leaf axils, 9–15-flowered; peduncle angular, 4–14 mm long. Flowers bisexual, regular, white; pedicel 2–7 mm long; flower buds obovoid, 4–7 mm × 2–4 mm, divided into an obconical hypanthium (lower part) c. 3 mm × 3–4 mm, and a conical operculum (upper part) 2–3 mm × 3–4 mm, shed at anthesis; stamens numerous; ovary inferior, usually 3-celled. Fruit an obconical to pear-shaped capsule 5–9 mm × 4–7 mm, opening with 3 valves. Seeds pyramidal, 1.5–3 mm long, brown. Seedling with epigeal germination.

Other botanical information *Eucalyptus* comprises about 800 species, endemic to Australia, except for about 10 species in the eastern part of South-East Asia. Many *Eucalyptus* species are cultivated outside their natural distribution area, in tropical, subtropical and temperate regions, because of their rapid growth and adaptation to a wide range of ecological conditions. *Eucalyptus* is divided into several subgenera (7–10, depending on the author), which are subdivided into many sections and series. The results of phylogenetic studies within *Eucalyptus* suggest that the genus is polyphyletic, hence not of a single evolutionary origin, and consequently it has been proposed to divide the genus into several distinct genera. This has not yet been done, mainly because of the nomenclatural whirlpool this would bring about. *Eucalyptus* species hybridize easily, which adds to the taxonomic complexity.

Growth and development *Eucalyptus regnans* seedlings first send down a strong taproot, and later produce lateral roots. Growth is initially slow, but increases rapidly in the second year. In the sapling stage trees have narrow, conical crowns 9–12 m high, lateral roots spread far and send down sinker roots. In the pole stage the tree is c. 30 m tall, with a conical crown, the sinker roots become branched and the taproot dies back. In the spar stage the crown spreads out and the tree reaches almost full height while the lateral and sinker roots become very well developed. In the mature stage the crown opens and starts to die back, and buttresses are present at the base of the tree. Overmaturity is characterized by trunk epicormic growth and progressive die-back of the central areas of crown and roots. Tree ages of 350–400 years have been recorded.

Flowering is protandrous and the flowers are pollinated by insects or birds. Both outcrossing and self-pollination occur. In controlled-pollination experiments seedlings produced after self-pollination showed reduced growth compared to those raised from open-pollinated seed. The time from flowering to seed maturation is 8–10 months. Unlike many other *Eucalyptus* species, *Eucalyptus regnans* does not regenerate from lignotubers. This means that mature trees are sensitive to intense fires, and that coppice harvests are usually not possible after the first harvest.

Eucalyptus regnans is the tallest hardwood species in the world. In Kenya at 2400 m altitude 2-year-old trees with a height of 9 m have been recorded, and 35-year-old trees with a height of 80 m. In a small plantation at 3000 m altitude 30-years-old trees were up to 80 m tall. Growth measurements are available from Tanzania as well. In a stand in the Shagayu Forest Reserve (1900 m altitude, average annual rainfall 1200 mm) trees had a mean height of 26.3 m and a mean diameter of 22.2 cm at age 8, and a mean height of 34.6 m and a mean diameter of 28.2 cm at age 12. In the Lushoto Arboretum (1500 m altitude, average annual temperature 18°C, average annual rainfall 1070 mm) 10-year-old trees were 32.0 m tall and 32.0 cm in diameter. In Olmotonyi (1850 m altitude) the average height of 13-year old trees was 29.8 m, and the average diameter 24.7 cm. In the Kigogo Arboretum (2000 m altitude, average annual rainfall 1800 mm) 32-year-old trees were 44–49 m tall, with a diameter of 65–89 cm.

Ecology *Eucalyptus regnans* prefers a cool climate. It grows in areas with a mean annual temperature of 7–20°C, a mean maximum temperature of the warmest month of 17–29°C, and a mean minimum temperature of the coldest month of –2 to +10°C. The average annual rainfall is 650–2000 mm, with a dry season of 0–2 months. It is intolerant of drought and severe cold (below –7°C). In its natural distribution area it occurs from sea level up to 1100 m altitude, while in tropical countries it usually grows at 2000–3200 m altitude. In provenance trials with 18 *Eucalyptus* species at 0–2800 m altitude in the wet tropics of Antioquia, Colombia, *Eucalyptus regnans* was the best performer at 2400 m altitude, and one of the three best at 2800 m altitude. It requires a moderately fertile, well-drained soil, and is sensitive to salinity.

Like many other *Eucalyptus* species, *Eucalyptus regnans* is very intolerant of competition for light and soil resources, which means that seedlings do not grow well under a pre-existing canopy. For this reason natural forests of *Eucalyptus regnans* are said to be self-thinning, i.e. the tallest, most dominant individuals shade out smaller individuals, which die. In native forests in south-eastern Australia *Eucalyptus regnans* grows in pure stands or as the canopy species, with an understory of *Acacia melanoxylon* R.Br. or *Acacia dealbata* Link.

Eucalyptus regnans has allelopathic effects on understory plants, especially on its own seedlings growing near mature trees or in fields in which mature trees have grown. These effects are alternately believed to be due to a buildup of waxy lipids in the soil from decaying *Eucalyptus regnans* leaves, or to a rhizosphere fungus, *Cylindrocarpon destructans*. The resulting difficulty of re-planting plantations of *Eucalyptus regnans* after harvest is a likely reason for the preference of *Eucalyptus globulus* Labill. in many plantations. However, seedling growth of *Eucalyptus regnans* is much stimulated when soil is exposed to fire or sterilization, which may be due to reduction or breakdown of inhibiting fungi or compounds in the soil. Hence natural stands are usually even-aged and can grow for centuries until they are stricken by a catastrophic fire, which kills all standing trees and stimulates massive seed germination. There is high mortality among these new seedlings and saplings, eventually leaving once again a mature, even-aged forest, which grows until the next periodic fire strikes.

The absence of lignotubers may be considered an advantage in terms of the ecological profile of *Eucalyptus regnans* outside of its native range. *Eucalyptus* species are often feared as invasive plants, and the lignotubers of many species make eucalyptus stands hard to eradicate once established. This risk is not present with *Eucalyptus regnans*, though mature trees are prodigious producers of seed.

Propagation and planting *Eucalyptus regnans* is usually propagated by seed. The 1000-seed weight is 5.5–12.5 g. Seed can be stored for several years in airtight containers under dry (5–8% moisture content) and cool (3–5°C) conditions. Cold and moist stratification of the seed at 3–5°C for 3 weeks is recommended to break dormancy and promote even germination. Germination is optimal at 15–20°C and usually takes 10–20 days. Seedlings raised in nurseries can be planted out after 8–9 months. In New Zealand *Eucalyptus regnans* seedlings are often grown in nursery beds for a year before bare-rooted seedlings are planted out in the field. Growing in polyethylene bags in the nursery is also possible. In-vitro propagation with microcuttings obtained from node-derived shoot cultures is possible.

Planting distances in the field usually range from 2 m × 2 m (2500 trees/ha) to 3 m × 3 m (1100 trees/ha). Planting for high-quality, large sawlogs must allow more space for each tree, and must be accompanied by pruning and thinning regimes. Closer spacing and higher densities can be used if the intended end product is pulp, fuel, or small posts, though rows of 3 m are necessary for mechanization, and a spacing of 3 m × 3 m is necessary for mechanized weeding in two directions. Another common strategy is to burn logging debris after harvest of a stand of *Eucalyptus regnans* and broadcast a large amount of seed (about 1 kg/ha) on the ash bed, eventually thinning the many trees that germinate and grow.

Management Weeding between rows (possibly mechanical) and hand weeding near seedlings is very important in the first year of growth, but becomes less critical after canopy closure. Young plants are commonly, but not universally, fertilized. In Tasmania fertilization with N greatly augmented growth, but recommended quantities vary with site conditions. High fertilizer rates risk acidifying the soil. Pruning is often considered to be unnecessary for *Eucalyptus* species, as they are largely self-pruning. However, allowing trees to self-prune by dropping branches can decrease wood quality by leaving knots and entrance points for decay. This is not a problem in plantations for pulp or fuel, but it can decrease the value of timber. Pruning of young branches can greatly improve timber quality by limiting knots to the innermost wood of the trunk. Pruning of young branches should coincide with canopy closure, as pruning before this point can slow down growth. The coppicing ability of *Eucalyptus regnans* is poor due to the absence of lignotubers.

Diseases and pests *Phytophthora fallax* is a fungal crown dieback disease of *Eucalyptus regnans* that occurs episodically in New Zealand, with individual trees showing differing degrees of susceptibility. Symptoms include leaf spots, petiole infection and branchlet lesions. *Mycosphaerella cryptica* is a leaf disease that can result in heavy defoliation and dieback. Certain provenances of *Eucalyptus regnans* are more susceptible than others, which implies that there is potential for breeding for resistance to the disease. No fungicides are known to give good control. Some fungi mainly affect seeds and seedlings, such as *Penicillium* spp., *Fusarium* spp., *Phytophthora* spp. and *Botrytis cinerea*, but they are not widely reported on *Eucalyptus regnans*, and good phytosanitary practices suffice to avoid them.

Eucalyptus regnans is one of the *Eucalyptus* species susceptible to the eucalyptus snout beetle (*Gonipterus scutellatus*), which occurs on all continents and is known to be present in Kenya, Uganda, Zimbabwe, South Africa, Mauritius and Madagascar. The eucalyptus snout beetle can be controlled with the hymenopterous parasite *Anaphoides nitens*. The longicorn beetle *Phoracantha semipunctata* is a borer that attacks young trees, stressed trees, and stumps of recently harvested trees. It has been recorded from Zimbabwe and South Africa. Insecticides are not effective, so it must be controlled by the removal and burning of infected material. The principal pest in *Eucalyptus regnans* plantations in Tasmania is *Chrysophtharta bimaculata*, a leaf eating beetle. It is controlled with an integrated approach involving insecticides and natural predators and parasites, together with strict monitoring of population numbers and breeding of more resistant trees. In Africa termites are a risk in *Eucalyptus* nurseries and young plantations up to 3–4 years old.

Harvesting For densely planted pulp or fuelwood plantations, harvesting occurs 8–15 years after planting, while plantations for large sawlogs are harvested when the plantation is 30–40 years old and has been thinned at age 10–12. The bark can be removed before the tree is felled by ringing the bark and pulling it upward in strips. However, this is not usually necessary, as rough bark only occurs at the base of *Eucalyptus regnans*, and this bark is usable in the paper pulping process. For larger trees debarking may need to occur after felling and sectioning of the trunk. Two men working with chainsaws can cut 300–500 trees a day in a well-ordered plantation. Clear-cutting of areas to be replanted to seedlings of *Eucalyptus regnans* is recommended, as standing trees are shown to have a strong negative effect on seedling growth.

Yield Under good conditions and with fertilization, mean annual volume increments of *Eucalyptus regnans* are 25–30 m^3/ha. In a 42-year-old plantation in Kenya mean annual volume increments of 56 m^3/ha have been recorded.

Handling after harvest Felled trunks may be sectioned into shorter lengths in the field to ease transport, and leaves, branches, and other waste may be localized in a few piles to facilitate circulation of people and vehicles. Pruning of branches after felling is usually unnecessary, as little branching occurs in dense plantations. On larger plantations with trees going to an off-site sawmill or pulping mill, trees or sections are dragged or carried to a road by manpower, animals, or tractors. Once near the road, the trees are picked up by a truck and taken to the plant. Trunks or sections can be left on the ground to air dry over months in areas where termites and rotting are not a problem. Air-drying on a paved lot reduces the risks of biological attack of the wood, and drying under a roof slows drying by reducing exposure to direct sun. This reduces the amount of tangential checking that is to some extent inevitable during the drying of round logs.

Genetic resources Breeding and provenance trial programs in Australia and New Zealand using progeny from hundreds of trees serve as a sort of in situ conservation of genetic diversity. In addition to this, natural and managed forests in south-eastern Australia and Tasmania preserve an estimated one third of the original natural genetic diversity of the species, as a large portion of them are the offspring of regeneration from original forest after fires or harvesting. Hence genetic erosion is not a serious threat, though the practice of replanting harvested forests with seedlings or direct seeding (common since 1960) amounts to a reduction of genetic diversity, since planted trees come from a limited number of accessions.

Breeding The main (perhaps only) breeding programs for *Eucalyptus regnans* are in Australia and New Zealand, and focus on frost resistance and rapid growth.

Prospects *Eucalyptus regnans* is not a major world plantation species, and *Eucalyptus globulus* is commonly used in the subtropical or high-altitude tropical environments well-suited to *Eucalyptus regnans*. *Eucalyptus regnans* is well-suited for the production of paper pulp, the most important product of industrial *Eucalyptus globulus*, but cannot substitute the latter as a source of eucalyptus oil. Little breeding work is done on *Eucalyptus regnans*, and hence most of the future world growth in eucalyptus planting and use will likely come from cosmopolitan species such as *Eucalyptus camaldulensis* Dehnh., *Eucalyptus globulus* and *Eucalyptus grandis* W.Hill ex Maiden. The unsuitability of *Eucalyptus regnans* wood for outdoor uses would somewhat limit its expansion in Africa. Another major issue is that *Eucalyptus regnans* does not possess lignotubers, and hence does not produce coppice regrowth. This is a disadvantage for intensive plantations because it means that trees must be replanted after every harvest, which, in combination with the poor growth of *Eucalyptus regnans* seedlings in soil from mature *Eucalyptus regnans* stands, may be the prime limitation to current and future use of *Eucalyptus regnans* in plantations.

Major references Ashton, 1975; Borota, 1991; CPBR, 2006; Eldridge et al., 1993; FAO, 1958; Forest Products Commission, 2008; Jacobs, 1981; Keane et al. (Editors), 2000; Montagu, Kearney & Smith, 2003; Verdcourt, 2001.

Other references Baker & Smith, 1920; Blomstedt et al., 1991; Booth et al., 1988; CAB International, 2010e; Coppen, 2002; Dick et al., 2006; Dignan et al., 1998; Ilvessalo-Pfäffli, 1995; Inderjit, Dakshini & Foy, 1999; McDougall et al., 1993; Penfold & Willis, 1961; Pérez et al., 2008; Phillips, 1993; Phillips, 1994; Raymond, 1995; Restrepo U. & Atehortua V., 1989; Ringrose & Neilsen, 2005; Timber Research Unit, 2007; Webb et al., 1984; Williams & Woinarski (Editors), 1997.

Sources of illustration Costermans, 1983.

Authors G. Vaughan

FICUS BUSSEI Warb. ex Mildbr. & Burret

Protologue Bot. Jahrb. Syst. 46: 213 (1911).

Family Moraceae

Chromosome number $2n = 26$

Vernacular names Busse's fig, Zambezi fig (En). Mkuyu, mtamba (Sw).

Origin and geographic distribution *Ficus bussei* is distributed from eastern DR Congo, Somalia and Kenya southward through Tanzania, Malawi and Zambia to Zimbabwe and Mozambique.

Uses String and rope are made from the bark. The wood is made into furniture and mortars. The root powder mixed with water is drunk for the treatment of impotence, cardiac pain and hysteria. A bark decoction is drunk in case of retention of the afterbirth. Ash from the bark is taken with butter against hiccups.

Botany Monoecious, medium-sized tree up to 25 m tall, often starting as an epiphyte; bole fluted, aerial roots often present; outer bark smooth, grey to dark brown, inner bark pale pink and brown, fibrous, with latex; young branches hairy to glabrous. Leaves spirally arranged, clustered near the ends of branches, simple; stipules up to 1.5(–5) cm long, glabrous or hairy at the base, caducous; petiole 2–8 cm long, hairy; blade ovate to oblong or elliptical, 5–30 cm × 3–11.5(–13) cm, base cordate, rarely rounded, apex acute to obtuse, margin entire to wavy, leathery, upper surface glabrous or hairy on midvein, lower surface glabrous or sparsely hairy, pinnately veined with (8–)9–16 pairs of lateral veins, with glandular spot at the base of the midvein beneath. Inflorescence a fig, the flowers enclosed within, figs 1–2 together in the leaf axils, globose or rarely ellipsoid, 1.5–3 cm in diameter, hairy, smooth or warted, green or yellow at maturity; peduncle 1–2.5 cm long, recurved; basal bracts 3–7 mm long, persistent, lateral bracts absent. Flowers unisexual; male flowers with 2–4 tepals and 1 stamen; female flowers with 2–4 tepals.

In southern Africa *Ficus bussei* flowers in September–February.

Ficus comprises about 750 species, with about

100 species in Africa, 500 species in tropical Asia and Australia, and 150 species in tropical America. In Central Africa the bark of various other *Ficus* species, including *Ficus lingua* De Wild. & T.Durand ex Warb. (synonym: *Ficus buxifolia* De Wild.), *Ficus preussii* Warb., *Ficus scassellatii* Pamp. (synonym: *Ficus michelsonii* Boutique & J.Léonard) and *Ficus wildemaniana* Warb. have been used for making cloth. *Ficus lingua* is a medium-sized hemi-epiphytic tree up to 30 m tall, distributed from Liberia and Côte d'Ivoire eastward through Central Africa to Kenya and Uganda, and from there southward to Mozambique and South Africa. *Ficus preussii* is a hemi-epiphytic shrub or small tree up to 10 m tall, occurring from Nigeria eastward through Central Africa to Uganda. *Ficus scassellatii* (Swahili name: mninga) is a small to large hemi-epiphytic tree up to 50 m tall, distributed from eastern DR Congo, Somalia and Kenya southward through Tanzania, Malawi and Zambia to Zimbabwe and Mozambique. *Ficus wildemaniana* a hemi-epiphytic shrub or tree, distributed from Cameroon eastward through Central Africa to Uganda. Cloth was made from these species by removing pieces of bark from the bole and large branches, soaking them in water for several days, drying them in the shade and beating them with a mallet to make them supple enough for use. *Ficus lingua* is also used for shade and outside tropical Africa as an ornamental plant, for instance as a bonsai tree. *Ficus scassellatii* is used for shade, amenity and grave marks; its latex is used for producing birdlime. The latex of *Ficus wildemaniana* is drunk with honey for the treatment of cardiac problems.

Ecology *Ficus bussei* occurs from sea-level up to 600(–1000) m altitude in lowland forest, woodland, riverine and swamp forest, coral rag forest and flood plains, occasionally at springs.

Genetic resources and breeding It is unclear whether *Ficus bussei* is threatened by genetic erosion.

Prospects *Ficus bussei* is known to be a local source of fibre for cordage, but no information is available on the properties of its fibre, making it difficult to assess its prospects. However, the species seems not important at present and is unlikely to gain importance in the future.

Major references Beentje, 1994b; Berg & Hijman, 1989; Dubois, 1951; Hauman, Lebrun & Boutique, 1948; Samuelsson et al., 1992.

Other references Berg, 1988; Friis, 1999; Hyde & Wursten, 2002; Lovett et al., 2007; Medley, 1993; Missouri Botanical Garden, undated; Neuwinger, 2000; Tanno, 1981; Terashima & Ichikawa, 2003; van Noort, Gardiner & Tolley, 2007.

Authors M. Brink

FICUS CAPREIFOLIA Delile

Protologue Ann. Sci. Nat. Bot., sér. 2, 20: 94 (1843).

Family Moraceae

Vernacular names Sandpaper fig, riverine sandpaper fig, river sandpaper fig, rough-leaved fig, willow wild fig (En). Arbre papier de verre (Fr).

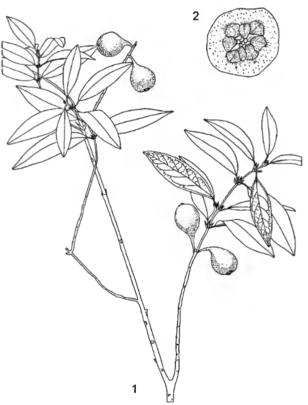
Origin and geographic distribution *Ficus capreifolia* is widely distributed in tropical Africa, from Senegal and Gambia eastward to Somalia and from there southward to Namibia, Botswana, Zimbabwe and Mozambique. It also occurs in South Africa and Swaziland.

Uses The bark, stripped off in long lengths, is used for making rope and string. Split twigs are used for plaiting baskets in Zimbabwe. The rough leaves are used as sandpaper for polishing wooden objects such as sticks, spears, bows, tool handles and earrings, and for the preparation of hides.

The leaf and the latex from the bark are used for tanning. The leaf is eaten in Senegal. The fruit is eaten and can be made into a fermented drink. The leaves, fruits and young shoots are used as fodder. Unspecified plant parts are used for construction of house roofs and as fuel. In Tanzania the leaf sap and a decoction of the root are taken for the treatment of schistosomiasis, and the leaf sap or the powdered root is sprinkled on syphilitic ulcers.

Properties The wood is soft. The latex from the bark is recorded to be urticant. A dichloromethane extract from the leaf has shown fungicidal activity against *Cladosporium cucumerinum*, due to the presence of the furanocoumarin psoralen. The extract also showed inhibitory activity on the enzyme acetylcholinesterase. A methanol extract of the twig has shown radical scavenging activity.

Botany Evergreen, dioecious shrub or small tree up to 8 m tall, occasionally lianescent; bole up to 80 cm in diameter; outer bark smooth, whitish, grey or greyish brown, inner bark pinkish, with watery or milky latex; young branches hairy. Leaves more or less distichous and alternate or almost opposite or verticillate; stipules free, linear to lanceolate, 0.5–1 cm



Ficus capreifolia – 1, flowering and fruiting twig; 2, fig in cross section.
Source: Flore analytique du Bénin

long, membranous, reddish, partly hairy, quite persistent; petiole up to 2(–2.5) cm long, scabrid, hairy or glabrescent; blade almost ovate to oblong or lanceolate, sometimes elliptical, 2–16.5 cm × 1–7 cm, base cordate to obtuse, apex acute, acuminate, obtuse, 3-lobed or 3-dentate, margin almost entire or slightly toothed, papery, both surfaces scabrid, pinnately veined with 4–12(–16) pairs of lateral veins, with glandular spots in the axils of the main lateral veins below. Inflorescence a fig, the flowers enclosed within, figs 1–2 together in the leaf axils, obovoid, ellipsoid or globose, 1–3.5 cm in diameter, stipe up to 5 mm long, hispidulous, green to pale yellow at maturity; peduncle 0.5–2 cm long; basal bracts 3, scattered or in a whorl, no bracts on the outer surface of the receptacle. Flowers unisexual; male flowers pedicellate, with 3–6 tepals and 1–3 stamens; female flowers with 4–6 tepals, 1-celled ovary and long style, seed flowers and gall flowers distinct.

Ficus comprises about 750 species, with about 100 species in Africa, 500 species in tropical Asia and Australia, and 150 species in tropical America.

Ficus capreifolia grows fast. Branches often root when they touch the ground, resulting in the formation of thickets. The flowers are pollinated by the wasp *Kradibia gestroi*. Fruiting is usually at the end of the dry season and the beginning of the rainy season. In southern Africa fruiting is recorded to occur in September–February. The fruits attract birds and fruit bats.

Ecology *Ficus capreifolia* occurs from sea level up to 2600 m altitude in low-rainfall coastal and riverine locations and swamps, often forming stands or thickets. It tolerates prolonged inundation.

Management *Ficus capreifolia* can be propagated by seed extracted from over-ripe or dried fruits and by cuttings, which root easily.

Genetic resources and breeding It is unknown whether *Ficus capreifolia* is threatened by genetic erosion.

Prospects *Ficus capreifolia* is a useful multipurpose plant, providing not only fibre, plaiting material and sandpaper, but also a range of other products, including food, fodder and traditional medicines. Unfortunately, information on properties, such as fibre, food and fodder quality, is lacking, making it difficult to assess the prospects for this species.

Major references Arbonnier, 2004; Berg & Hijman, 1989; Burkill, 1997; Friis, 1989a; SEPASAL, 2009c.

Other references Cavendish, 1999; Coates Palgrave, 1983; Cogne, 2002; Friis, 1999; Heine & Heine, 1988a; Johnson, Johnson & Nichols, 2002; Neuwinger, 2000; Stave et al., 2007; Stefanesco & Bintoni-Juliassi, 1982; Vivien, 1990.

Sources of illustration Akoègninou, van der Burg & van der Maesen, 2006.

Authors M. Brink

FICUS EXASPERATA Vahl

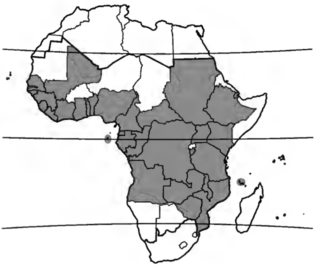
Protologue Enum. pl., 2: 197 (1805).

Family Moraceae

Vernacular names Forest sandpaper fig, forest sandpaper tree, sandpaper tree, sandpaper leaf tree, white fig tree (En). Papier de verre (Fr). Msasa, mkuyu (Sw).

Origin and geographic distribution *Ficus exasperata* is widely distributed in tropical Africa, from Senegal eastward to Ethiopia and Djibouti and southward to Mozambique and Angola. It also occurs in Yemen, India and Sri Lanka.

Uses The rough leaves are widely used as



Ficus exasperata – wild

sandpaper for polishing wooden, metal or ivory articles, such as kitchen utensils, gourds, sticks, bows, spear shafts, chairs, boards and bracelets.

The wood is used for making canoes, house posts, furniture, stools, utensils, containers and drums, and is also used as fuelwood and for making charcoal. Young branches are used for making pipe stems. Although the leaf is sometimes recorded to be poisonous to goats and sheep, it is often fed to ruminants, especially in Ghana. In Nigeria the fresh leaf is locally added to oil palm fruits in the milling or pounding stage, to improve the quality and stability of the oil obtained. *Ficus exasperata* has been planted as an avenue shade tree, and wild trees are sometimes maintained as a shade tree in banana, coffee or cocoa plantations.

Ficus exasperata is widely used in African traditional medicine. Root decoctions are taken for the treatment of urinary tract ailments, gonorrhoea, asthma and tuberculosis. The root is chewed in case of cough. The root bark is used against eye problems. The body is rubbed with root scrapings as a tonic. In Ghana the root is an ingredient in a prescription to expel worms. Wood ash or charcoal is applied on lesions caused by leprosy. Sap from the stem bark is used for the treatment of wounds, sores, abscesses, eye ailments, stomach-ache and for the removal of spines, but some traditional healers consider it corrosive to the skin and dangerous to ingest. The ash of burnt stem bark is sprinkled on wounds. Decoctions of the bark are taken against worms, haemorrhoids and abnormal enlargement of the spleen. They are also used as ingredients in the treatment of heart problems. A tisane or decoction of the bark is taken to relieve cough. A cold bark extract is drunk in case of dizziness. A maceration of the bark with *Senna occidentalis* (L.) Link and *Setaria megaphylla* (Steud.) T.Durand & Schinz is taken to facilitate childbirth or to heal gonorrhoea. Sap from the bark is used to halt bleeding. Scrapings from the bark are made into an embrocation with stimulant and tonic properties. The stem bark is locally applied on the body for the treatment of malaria. A maceration of the young shoot is drunk as an emetic. A decoction of the leafy shoot is taken for the treatment of dysentery. The leafy shoot is used in preparations applied externally against jaundice or drunk as a diuretic. Leaf pulp or sap is externally applied for the treatment of rash, wounds, leprous sores, fungal infections, itching, oedema, ringworm, rheumatism, and lumbar and intercostal pain. The powder of the dried leaf is sprinkled on burns. The young leaf is chewed and swallowed in case of gastric ulcers. The leaf juice or a decoction of the leaf is applied as an enema for the treatment of stomach-ache, and as an antidote to poison. Decoctions of fresh or dried leaves are taken for the treatment of diseases of the kidneys and urinary tract. Leaves cooked with bananas are eaten for the treatment of gonorrhoea; the cooking water is drunk for the same purpose. In Nigeria a decoction or maceration of the leaf is taken to lower blood pressure, and the fresh leaf is used as an ingredient of preparations for the treatment of heart diseases. Leaf preparations are taken for the treatment of cough, colds, flu and asthma, and they are a mouthwash against thrush, inflammation of the gums and other mouth and throat ailments. The head is rubbed with warmed leaves for the treatment of headache; tumours are also rubbed with warmed leaves. In case of severe headache, the patient's head is washed with a decoction of the leaf. The leaf pulp diluted in water is credited with analgesic properties and applied for the treatment of eye ailments; water in which a leaf has been shaken is used similarly. A maceration of the leaf is taken as an oxytocic, while a decoction or infusion of the leaf is drunk as an abortifacient. The abrasive leaf surface is used to scarify the skin to promote penetration of medicines, and to scour the tongue and throat for the treatment of mouth and throat ailments. The leaf is also used to scratch itching parts of the body and is ingested for mechanical treatment of diarrhoea and intestinal worms. The fruit is eaten against cough and venereal diseases. Powder of the dried fruit is added to porridge for the treatment of sterility in women. Water with seed powder is drunk as a tonic in case of fever.

In veterinary medicine a decoction of the bark is given to cows to hasten expulsion of the afterbirth. The stem bark and the leaf are ingredients of arrow-poisons. In Nigeria a maceration of the leaf is sprayed on crops against insect attack.

Properties Although the leaves are widely used as sandpaper, they are not as abrasive and strong as commercial sandpaper. Reports on the wood properties are contradictory. The fibre length of wood from Nigeria is 1.5–2.2 mm, with a diameter of 21.5–23.5 µm, a lumen diameter of 11–13 µm and a cell wall thickness of 4–7 µm.

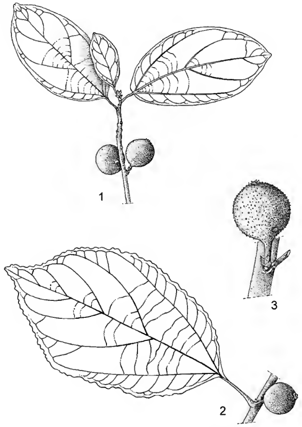
In Nigeria *Ficus exasperata* forage (leaves plus stems less than 6 mm in diameter) contained 14.6 g and 19.9 g crude protein per 100 g dry matter in the wet and dry season, respectively. Leaves collected at the end of the rainy season in southern Ghana contained 4.1 g N per 100 g dry matter. The leaves are said to be harmful to cattle due to their roughness.

The inclusion of *Ficus exasperata* leaves in the processing of oil palm resulted in better stabilization of the oil in Nigeria. The anti-oxidant activities were enhanced whereas saponins, where present, were eliminated and sterols reduced.

Aqueous extracts of the leaf showed in-vivo gastrointestinal protective effects, diuretic activity and lipid-lowering effects in rats, and hypotensive effects in rabbits. At higher concentrations they stimulated contractions of the isolated rat uterus, whereas at lower concentrations they inhibited oxytocin-induced uterine contractions. An ethanolic extract of the leaf showed in-vivo analgesic and anti-inflammatory activity and weak antipyretic activity in mice, chicks and rats, respectively. Methanolic plant extracts have shown in-vitro antitumour activity and inhibition against trypsin activity. Aqueous and ethanolic extracts of the leaf did not show any toxicity in various bioassays. Aqueous and methanolic extracts were inactive against several gram-negative and gram-positive bacteria. A compound with nematicidal activity, 5-methoxysporalen, has been isolated from the leaf. The content was six times higher in young leaves than in mature leaves. Cowpea pods treated with *Ficus exasperata* leaf powder before being stored under traditional conditions showed decrease in both the percentage of beans with *Callosobruchus maculatus* and the number of emerged beetles. The stem and leaf contain alkaloids, flavonoids, tannins and cyanogenic glycosides. The fruit contains flavonoids and xanthones.

Adulterations and substitutes *Ficus asperifolia* Miq. is similarly used in traditional medicine and the preparation of arrow poisons.

Description Deciduous, dioecious shrub or small to medium-sized tree up to 20(–30) m tall; bole up to 50 cm in diameter, sometimes fluted or buttressed; outer bark smooth, pale grey-green to brownish, inner bark creamy white to pale brown, without latex, but exuding a clear, viscid, non-milky sap on cutting; crown spreading; young branches hispidulous. Leaves almost distichous and alternate, sometimes almost opposite, simple; stipules free, lanceolate, up to 0.5 cm long, covered with stiff hairs, caducous; petiole 0.5–6 cm long, scabrid; blade ovate to elliptical or obovate, sometimes oblong or subcircular, in young plants often lobed, 2.5–17.5(–20) cm × 1–12 cm, base acute to obtuse,



Ficus exasperata – 1, twig with figs; 2, leaf and fig; 3, fig.
Redrawn and adapted by Achmad Satiri Nurhaman

sometimes almost cordate, apex shortly acuminate, acute or obtuse, margin toothed to entire, papery or leathery, upper surface scabrid, lower surface scabrid and hairy, pinnately veined with 2–5(–6) pairs of lateral veins, with glandular spots in the axils of the main lateral veins below. Inflorescence a fig, the flowers enclosed within, figs 1–2 together in the leaf axils, just below the leaves or on older wood, globose to ovoid, 1–3 cm in diameter, often stiped, hispidulous, pink, purplish, yellow, orange or red at maturity; peduncle 0.5–1(–2.5) cm long, scabrid; bracts broadly ovate, 1–5 scattered on the peduncle (basal bracts) and 1–4 on the outer surface of the receptacle (lateral bracts). Flowers unisexual; male flowers with 3–6-lobed perianth and 1–3 stamens; female flowers with 4–6 tepals, seed flowers and gall flowers distinct.

Other botanical information *Ficus* comprises about 750 species, with about 100 species in Africa, 500 species in tropical Asia and Australia, and 150 species in tropical America. *Ficus exasperata* is often confused with *Ficus asperifolia* because both species have scabrid leaves. *Ficus exasperata* is distinguished by its leaf blade being more uniformly symmetrical and having 3–4 pairs of prominent, up-curving lateral veins, whereas that of *Ficus asperifolia* tends to be asymmetric and to have 6–8 less prominent lateral veins.

Growth and development The fig is not a fruit but a fruit-like structure (syconium) developed from an inside-out flower stalk containing many flowers inside. *Ficus exasperata* trees are either female, with inflorescences bearing long-styled female flowers, or hermaphrodite, with inflorescences bearing male and short-styled female flowers (gall flowers). The hermaphrodite trees are functionally male, because the contents of their pollinated ovaries are consumed by wasp larvae, and they do not produce seeds. *Ficus exasperata* is pollinated by the wasp *Kradibia gestroi*, which lays eggs in the short-styled female flowers, but cannot lay eggs in the long-styled flowers of the female trees. Fruiting is usually in the dry season, in Ghana in December–March.

Ecology *Ficus exasperata* occurs from sea level up to 2300 m altitude in forest, often at edges, in secondary vegetation, in rocky places and along rivers, sometimes persisting in cleared land. It is also found in abandoned fields and along roads.

Propagation and planting *Ficus exasperata* can be propagated by seed and cuttings. Wildlings are also used.

Management After having been cut, trees regenerate through sprouting from the stump.

Genetic resources In view of its wide distribution, occurrence in secondary vegetation and ability to persist in cleared land, *Ficus exasperata* seems not threatened by genetic erosion. However, local over-exploitation has been recorded, for instance in central Uganda, where wild trees are logged for making drums and on-farm planting of the tree is recommended.

Prospects *Ficus exasperata* is widely used as local source of sandpaper and as a medicinal plant. Its role as a source of sandpaper is unlikely to go beyond local use, because of the availability of commercial sandpaper, which is more abrasive and stronger. However, the plant may become more important as a source of medicine, as various extracts have shown anti-ulcer, hypotensive, lipid-lowering, analgesic, anti-inflammatory and antipyretic activity.

Major references Akah et al., 1998; Arbonnier, 2004; Ayinde, Omogbai & Amaechina, 2007; Berg & Hijman, 1989; Burkill, 1997; Friis, 1989a; Katende, Birnie & Tengnäs, 1995; Neuwinger, 1998; Neuwinger, 2000; Woode et al., 2009.

Other references Adesope et al., 2006; Aké Assi, 1990; Amonkan et al., 2005; Apori et al., 1998; Bafor, 2009; Bafor & Igbinuwen, 2009; Betti, 2001; Boeke et al., 2004; Igoli et al., 2005; Irvine, 1961; Koshimizu et al., 1993; Larbi et al., 1998; Lovett et al., 2007; Nimenibo-Uadia, 2003; Omeja, Obua & Cunningham, 1995; Patel, 1996; Rodriguez & Wrangham, 1993; Sowemimo et al., 2007; Umerie et al., 2004; Yamada, 1999.

Sources of illustration Berg, Hijman & Weerdenburg, 1984.

Authors R. Niangadouma

FICUS NATALENSIS Hochst.

Protologue Flora 28: 88 (1845).

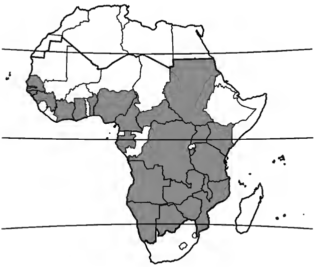
Family Moraceae

Chromosome number $2n = 26$

Synonyms *Ficus leprieurii* Miq. (1867).

Vernacular names Bark-cloth fig, Natal fig, common wild fig, strangler fig (En). Figuier de Natal (Fr). Mlumba, mlandege (Sw).

Origin and geographic distribution *Ficus natalensis* occurs from Senegal eastward to Sudan and southward to DR Congo and Angola, and from Kenya southward to South Africa.



Ficus natalensis – wild

Uses The bark of *Ficus natalensis* used to be an important source of bark cloth. In Uganda this cloth adorns cultural sites and shrines, and is used in burying the dead. It is used in ceremonies, but also as bedding material and in handcrafts, and it is sold in curio-shops and local markets. The bark is also made into cordage.

The fruit is edible, but of marginal importance; in West Africa it is eaten by children. In Uganda dried and pounded fruits are mixed with cassava flour to make bread. Leaves are given to domestic animals as fodder. The tree is planted in live fences or hedges around homesteads, as an avenue tree, or as a shade tree in coffee, cocoa, and banana plantations. It is also used as landmark. The wood is used to carve household utensils, as house-posts and as firewood. In South Africa the soft wood is used to make 'fire sticks'. The latex is used as glue and bird-lime. *Ficus natalensis* is grown as a bonsai plant.

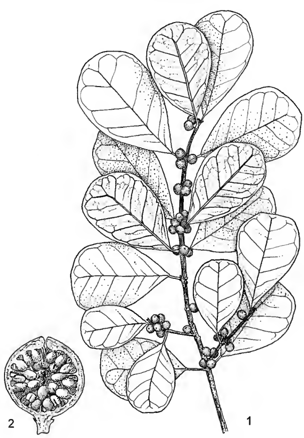
In African traditional medicine, all parts of the tree are applied against a variety of ailments. The root has analgesic properties and is used in Senegal for the treatment of lumbago, arthritis and headache. In Uganda the root is applied to the eye for the treatment of cataract. In Tanzania the root enters into antivenom against snake-bites, in Uganda an infusion of the leaves is drunk for this purpose. In eastern Tanzania a root decoction is drunk against malaria, and in southern Africa against colic. A maceration of the bark is drunk regularly during pregnancy to ease childbirth. In Tanzania, the bark is used as a galactagogue and against influenza and whooping cough. Bark or root pulp is rubbed in against headache. The latex is credited with analgesic properties and is used in Senegal against toothache. It also enters into preparations against guinea-worm. In Uganda an infusion of the aerial roots is taken against hiccup. In Uganda sap squeezed from the aerial roots and the leaves is drunk or the aerial roots are chewed to induce labour, while an infusion of the root is drunk against retained placenta. Also in Uganda water in which leaves of *Ficus natalensis* and other plants are steeped is drunk in large amounts against dysentery. In Sierra Leone the leaves are externally applied to stop internal bleeding. Zulu people in South Africa apply pulped leaves to ulcers, wounds and warts. In Tanzania the leaf sap is also applied against septic ears. In Uganda leaves form part of a treatment of malaria.

Production and international trade Bark cloth sheets are mainly traded locally, but there are small exports, especially in handicrafts, mostly to Europe.

Properties In Nigeria the suitability of *Ficus natalensis* for pulp and paper making has been tested. The wood contained 32% fibre by volume. The ultimate fibres were c. 1 mm long, with a diameter 23 μm and a cell wall thickness of 3.2 μm. The wood was fairly suitable for paper-making.

A methanol extract of the root has shown some antibacterial activity against *Staphylococcus aureus*, *Staphylococcus epidermis* and *Bacillus subtilis*. In a test in Nigeria, the essential oil obtained from the leaves was dominated by (E)-phytol (37.6%) and 6,10,14-trimethyl-2-pentadecanone (24.9%).

Description Shrub or small to medium-sized tree up to 30 m tall, semi-epiphytic or secondarily terrestrial; bole short; bark greyish, fairly smooth, with white latex; crown spreading to sometimes semi-scandent or lianous; aerial roots hanging from branches, few or abundant; leafy twigs 2–5 mm thick, glabrous or sparsely minutely puberulous. Leaves spirally arranged, almost distichous, or nearly opposite, simple; stipules 2–10 mm long, glabrous or puberulous, caducous; petiole 0.5–3 cm long, glabrous; blade oblong to elliptical or obovate to broadly obtriangular, occasionally lanceolate, 2.5–10(–11) cm × 1–4.5(–8) cm, acute to obtuse at the base, shortly acuminate, subacute, rounded or emarginate at the apex, margin entire, thin leathery, both surfaces glabrous, lateral veins in 5–13 pairs, midvein usually not reaching the apex, tertiary venation reticulate or nearly



Ficus natalensis – 1, flowering branch; 2, fig in longitudinal section.
Redrawn and adapted by H. de Vries

parallel to the lateral veins. Inflorescence a fig, the flowers enclosed within, figs in pairs in the leaf axils or sometimes also just below the leaves, globose to ellipsoid or obovoid, 1.5–2 cm in diameter when fresh, 1–1.5 cm in diameter when dry, glabrous, reddish-orange or yellowish to brown at maturity, usually wrinkled when dry; peduncle 2–10 mm long; basal bracts 1.5–2.5 mm long, caducous, sometimes shortly persistent. Flowers unisexual; male flowers with 2–3 tepals and 1 stamen; female flowers with 3 tepals, seed flowers sessile and with style 1.5–2 mm long, gall flowers on pedicel up to 1 mm long and with style 0.5–1 mm long. Fruit ellipsoid, c. 1.5 mm long, developing within the fig; 'gall fruits' subglobose, c. 1 mm long.

Other botanical information *Ficus* comprises about 750 species, distributed in tropical and subtropical regions, with a few species in warm temperate regions. About 100 species occur in Africa, 500 in Asia and Australia, and 150 in the Americas. *Ficus natalensis* is classified in subgenus *Urostigma* section *Galoglychia* subsection *Chlamydodorae*. It is easily confused with *Ficus faulkneriana* C.C.Berg, *Ficus thonningii* Blume and *Ficus craterostoma* Warb. ex Mildbr. & Burret, but can be distinguished by its pedunculate figs with caducous basal bracts. The close relation between *Ficus natalensis* and the latter 2 species is confirmed by molecular analysis.

Within *Ficus natalensis*, 3 subspecies are recognized: subsp. *natalensis* ('coastal strangler fig'), distributed in East tropical Africa and coastal South Africa; subsp. *graniticola* J.E.Burrows ('granite-boulder fig', 'natal fig'), growing inland in Zimbabwe, probably also in western Mozambique and northern South Africa, differing from subsp. *natalensis* in its leathery, often grey-green leaves, the often truncate leaf apex and the larger figs which are yellow when ripe; and subsp. *leprieurii* (Miq.) C.C.Berg, distributed from Senegal to southern Sudan and southwards to eastern DR Congo, Zambia and to northern Angola, differing from subsp. *natalensis* in its often shrubby, scandent habit, obovate to obtriangular leaves and small figs.

There is evidence for hybridization between *Ficus natalensis* subsp. *natalensis* and *Ficus thonningii* in Natal, and both species are pollinated by the wasp *Elisabethiella stuckenbergi*. On the other hand, *Ficus natalensis* subsp. *natalensis* and subsp. *leprieurii* are pollinated by different wasp species; the latter by *Alfonsiella fimbriata*. As the relation between fig species and pollinator species is usually very close and taxonomically relevant, the taxonomy of *Ficus natalensis* and *Ficus thonningii* may need revision.

Growth and development *Ficus natalensis* starts life as a soil-based seedling or as an epiphyte, later becoming a strangler and eventually replacing the original tree. Pollination is effectuated by several species of fig-wasps (*Agaonidae*). While mostly 1 fig species is associated with 1 wasp species and vice versa, 4 wasp species were found to visit a single *Ficus natalensis* tree in Uganda. In West Africa fruits ripen during the first half of the dry season, or during the beginning of the rainy season.

Ecology *Ficus natalensis* occurs from sea-level up to 2200 m altitude in wet forest as well as in dry forest, thicket, and riverine and ground-water forest in woodland and savanna, often in rocky places.

Propagation and planting Large cuttings and seedlings can be used as planting material. Fruits dry without releasing the seed. They can be stored for some time provided insect attack is controlled, e.g. by adding ash.

Management *Ficus natalensis* is an important agroforestry tree, for instance in banana plantations in Uganda. It coppices well.

Harvesting For cloth-making, a cylinder of bark is removed from the bole. After removal of the bark, the bole is covered with banana leaves, and sometimes plastered with cow dung, to stimulate recovery and new bark growth. It is said that well-managed trees can be harvested annually for up to 40 years, provided the cambium is not damaged. Regrown bark is reported to be of better quality than bark from the first harvest.

Handling after harvest To make bark-cloth, the harvested cylinder of bark is softened with steam and intensively beaten with a mallet to remove unwanted material and to stretch the bark. A 50 cm wide piece of bark can yield a piece of cloth nearly 2.5 m wide after beating. After being beaten the cloth is left to dry in the sun, which also gives it a deep red-brown colour. The darkening can be stopped any time. After drying, the bark is moistened and kneaded until soft and pliable.

Genetic resources *Ficus natalensis* is widespread and cultivated. It is not in danger of genetic erosion.

Prospects Bark-cloth has lost most of its commercial importance, but is still produced. Continued interest from the curio and souvenir industry and handicraft world-wide ensure a small but steady demand. While the wood is fairly suitable for paper making, the suitability of *Ficus natalensis* as a plantation pulp species remains to be investigated. The growth rate and other factors determining production and economics have to be evaluated and taken into consideration. The important role of *Ficus natalensis* in African traditional medicine is not reflected by pharmacological research and investigation of its potential is urgently needed.

Major references Arbonnier, 2000; Berg, 1988; Berg, 1991; Burkill, 1995; Grace et al., 2002; Katende, Birnie & Tengnäs, 1995; Neuwinger, 2000; Ogunkunle, 2010; Rabe & van Staden, 1997; Tabuti, Lye & Dhillion, 2003.

Other references Adriaens, 2005; Beentje, 1994b; Bekunda & Woomer, 1996; Berg, Hijman & Weerdenburg, 1985; Burrows & Burrows, 2003; Coates Palgrave, 2002; Compton, Grehan & van Noort, 2009; Hauman, Lebrun & Boutique, 1948; Ipulet, 2007; Kamatenesi-Mugisha & Oryem-Origa, 2007; Keay, 1958f; Kokwaro, 1993; Lovett et al., 2006; Ramcharun, Baijnath & van Greuning, 1990; Renoult et al., 2009; Rønsted, Salvo & Savolainen, 2007; Rønsted et al., 2008; Sonibare et al., 2009; Tabuti et al., 2011; van Wyk & Gericke, 2000.

Sources of illustration Hauman, Lebrun & Boutique, 1948.

Authors L.P.A. Oyen

FICUS POLITORIA Lam.

Protologue Encycl. 2: 500 (1788).

Family Moraceae

Synonyms *Ficus soroceoides* Baker (1883).

Origin and geographic distribution *Ficus politoria* is endemic to Madagascar.

Uses The leaf is used as sandpaper to polish wood and metals. The pounded bark was formerly used for making loincloth. The wood is used in the construction of house frames. Reports on the edibility of the fruit are contrasting.

In traditional medicine in Madagascar a decoction of the young leaf or bud is taken for the treatment of stomach-ache. An infusion of the leaf is given as a tonic to sick people. The abrasive leaf surface is used to scarify the skin to promote penetration of medicines.

Botany Dioecious shrub or small tree up to 8(–15) m tall; bole up to 15 cm in diameter; outer bark of leafy branches scabrid to smooth, when dry pale to dark brown or greyish, in older parts flaking off, inner bark with milky latex; branches scabrous to smooth, hispidulous to almost glabrous. Leaves almost distichous, sometimes opposite, simple; stipules up to 0.5 cm long, glabrous, caducous; petiole up to 1(–3) cm long, sparsely hispidulous; blade elliptical to oblong, obovate, lanceolate, orbicular or linear, 1.5–10(–16) cm × 1–4(–6.5) cm, often slightly unequal-sided, base acute to rounded, apex acuminate, sometimes 3-dentate, margin irregularly toothed to almost entire, papery to leathery, upper surface scabrid, sparsely hispidulous, lower surface scabrid and hispidulous, pinnately veined with 4–8(–10) pairs of lateral veins, with glandular spots in the axils of the main lateral veins below. Inflorescence a fig, the flowers enclosed within, figs 1–2(–4) together in the leaf axils or on older wood, globose, 0.5–1 cm in diameter when dry, hispidulous, yellow, orange, red or red-brown at maturity; peduncle up to 1(–2.5) cm long, hispidulous; basal bracts 3–4, ovate, c. 0.5 mm long. Flowers unisexual; male flowers sessile or short-pedicellate, tepals 4–5(–6), 1–1.5 mm long, stamens 1(–2); female flowers with 4–6 tepals (1–)1.5–2 mm long, seed flowers sessile or on pedicel up to 1.5 cm long, gall flowers sessile or on pedicel up to 1 mm long. Fruit ellipsoid to ovoid, c. 1 mm long, developing within the fig; 'gall fruits' ellipsoid to ovoid, 1.5–2 mm long.

Ficus politoria is pollinated by the wasp *Kradibia saundersi.*

Ficus comprises about 750 species, with about 100 species in Africa, 500 species in tropical Asia and Australia, and 150 species in tropical America.

Ecology *Ficus politoria* occurs from sea level up to 1700(–2000) m altitude in forest and disturbed vegetation.

Genetic resources and breeding It is unclear whether *Ficus politoria* is threatened by genetic erosion, but it seems rather common in Madagascar as it has often been collected.

Prospects *Ficus politoria* is used for polishing, construction and medicinal purposes. No information is available on its properties in relation to its uses, so its prospects cannot properly be assessed.

Major references Berg, 1986; Boiteau, Boiteau & Allorge-Boiteau, 1999; Perrier de la Bâthie & Leandri, 1952.

Other references Debray, Jacquemin & Razafindrambao, 1971; Decary, 1946; Kremen et al., 1996; van Noort & Rasplus, 2007.

Authors M. Brink

FICUS TREMULA Warb.

Protologue Bot. Jahrb. Syst. 20: 171 (1894).

Family Moraceae

Synonyms *Ficus kimuenzensis* Warb. (1904).

Vernacular names Quiver-leaf fig (En). Mvumo, uzi (Sw).

Origin and geographic distribution *Ficus tremula* is distributed from Nigeria southward to Angola, and from Rwanda, Burundi, Kenya and Uganda southward to Mozambique and South Africa.

Uses The bark is made into very strong string. In Kenya this string is used for making fish-traps, and the root for making woven bags. The tree provides shade and amenity.

Botany Monoecious shrub, small tree or liana up to 15 m tall, with aerial roots; outer bark smooth, pale grey, not flaking off, inner bark fibrous, with milky, white latex; young branches sparsely hairy to glabrous. Leaves spirally arranged, simple; stipules free, up to 1(–3) cm long, glabrous, caducous; petiole 0.5–4.5 cm long; blade oblong, elliptical, ovate or obovate, 2–11 cm × 0.5–5 cm, base obtuse to rounded to emarginate or cordate, apex acute to acuminate, margin entire, papery to leathery, both surfaces glabrous or the midvein hairy beneath, pinnately veined with 5–9 pairs of lateral veins, with glandular spot at the base of the midvein beneath. Inflorescence a fig, the flowers enclosed within, figs 1–6 together on curved spurs up to 3 cm long on older wood, globose to ellipsoid, 1–3.5 cm in diameter, densely hairy to glabrous, greenish to brown at maturity; peduncle 0.5–3 cm long; basal bracts 2, 2–3 mm long, lateral bracts absent. Flowers unisexual; male flowers with 2–4 tepals and 1–4 stamens; female flowers with 2–4 tepals. Fruit ellipsoid to ovoid, 1.5–2 mm long, developing within the fig.

Ficus comprises about 750 species, with about 100 species in Africa, 500 species in tropical Asia and Australia, and 150 species in tropical America. Within *Ficus tremula* 3 subspecies are distinguished:

- subsp. *tremula* (Swahili names: mvumo, uzi): tree or sometimes a climber, twigs usually drying yellowish or greyish, leaf blade mostly drying dark brown above and greenish beneath, base of leaf blade rounded to emarginate; distributed from Kenya southward to Zimbabwe, Mozambique and South Africa; occurring from sea-level up to 600 m altitude in lowland dry evergreen forest, woodland and coastal bushland.
- subsp. *acuta* (De Wild.) C.C.Berg (synonym: *Ficus acuta* De Wild.): tree or often a liana, twigs drying brown to blackish, leaf blade drying brownish at both surfaces, base of leaf blade obtuse to rounded; distributed in DR Congo, Rwanda, Burundi, Kenya and Uganda; occurring at 1650–2300 m altitude in upland rainforest.
- subsp. *kimuenzensis* (Warb.) C.C.Berg (synonym: *Ficus kimuenzensis* Warb.): small tree or often a climber, twigs drying dark red-brown to blackish, leaf blade drying brownish without strong colour contrast between both surfaces, base of leaf blade cordate to rounded; distributed from Nigeria southward to Angola; occurring at low altitudes in forest and savanna.

The flowers of subsp. *tremula* and subsp. *acuta* are pollinated by the wasp *Courtella wardi.* In southern Africa *Ficus tremula* fruits in October–November.

Ecology *Ficus tremula* occurs from sea-level up to 2300 m altitude in forest, woodland and bushland.

Genetic resources and breeding It is unclear whether *Ficus tremula* or any of its subspecies are threatened by genetic erosion.

Prospects *Ficus tremula* provides string, but very little information is available on other uses of the fibre and its properties. The species is only locally used and is unlikely to become more important in the future.

Major references Beentje, 1994b; Berg, 1988; Berg & Hijman, 1989; Burkill, 1997; Lovett et al., 2007.

Other references Berg, 1991; Berg, Hijman & Weerdenburg, 1984; Berg, Hijman & Weerdenburg, 1985; Coates Palgrave, 1983; Medley & Kalibo, 2007; van Noort & Rasplus, 2007; van Noort, Gardiner & Tolley, 2007.

Authors M. Brink

FLAGELLARIA GUINEENSIS Schumach.

Protologue Beskr. Guin. pl.: 181 (1827).

Family Flagellariaceae

Chromosome number $2n = 36, 38$.

Vernacular names Kanoti grass (En). Mpepa, mpewa, mteba, nkalamu (Sw).

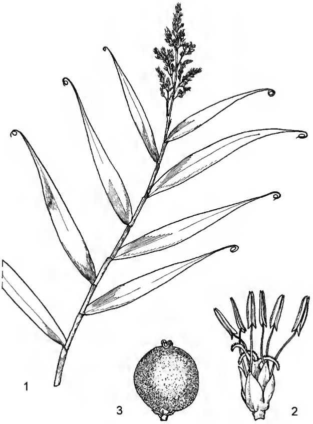
Origin and geographic distribution *Flagellaria guineensis* occurs in most of mainland tropical Africa and South Africa.

Uses The stems are used for hut construction and to make necklaces in Gabon. In Tanzania they are used for making fish traps, and in Transkei (South Africa) for weaving and basketry.

The fruits are sometimes eaten in Tanzania and Mozambique. In Tanzania the seed is made into porridge eaten during periods of severe food shortage, even though it causes stomach problems. The plant is a forage for all livestock. In Tanzania pieces of the stem are used as writing pens. The wood is used as fuel. The plant has ornamental value. The rhizome is fed to hunting dogs to improve their sense of smell.

In traditional medicine in Côte d'Ivoire a decoction of leafy twigs is used as a wash or vapour bath to cure kidney pain. Leaf decoctions are drunk as a cure for gonorrhoea and used as a mouth wash against dental caries. Leaf pulp is also applied in case of dental caries. In Gabon the leaves are credited with aphrodisiac properties. In Kenya boiled leaves are applied hot for the treatment of hernia, and the twigs and leaves are used to heal venereal diseases. In south-western Tanzania an extract of the fruits is drunk to cure venereal diseases, while a dressing of pulped fruits is applied externally to cure venereal disease and skin problems. In Somalia the whole plant is crushed and mixed with oil and applied externally against rheumatic pains. In Tanzania ash from burnt plants mixed with seed oil of *Ricinus communis* L. is rubbed into scarifications on the temple against headache. Plant ash is also applied on ruptures in Tanzania, and against hernia in Kenya. In Tanzania unspecified plant parts are used against asthma and other chest problems.

Botany Perennial climber up to 10 m long with sympodial rhizomes; stems slender, up to 2.5 cm in diameter. Leaves alternate, entire; sheath 4–12 cm long, often split to the base but at least split for one third of its length; blade oblong-lanceolate, up to 18 cm × 2.5(–3) cm (excluding the leaf-tip tendril), base often abruptly widened, apex ending in a coiled tendril, glabrous, venation parallel. Inflorescence a terminal panicle 8–12 cm long; side branches are short racemes. Flowers subsessile, bisexual, 6-merous; perianth segments 6(–8) in 2 whorls, erect, ovate, 2–3 mm long; stamens as many as perianth segments, in 2 whorls, exserted, attached to the base of the perianth



Flagellaria guineensis – 1, part of flowering stem; 2, flower; 3, fruit.
Source: Flore analytique du Bénin

segment, filaments free, anthers introrse; ovary superior, globose, glabrous, style and perianth persistent. Fruit a globose, fleshy drupe 5–9 mm in diameter, red, 1(–2)-seeded. Seed globose.

Flagellaria comprises 3 or 4 species and is distributed in the tropical regions of the Old World and Australasia. The closely related *Flagellaria indica* L., a climber up to 15(–20) m long, differs from *Flagellaria guineensis* by its entire leaf sheath and more compact inflorescences. *Flagellaria indica*, known as 'rotan du pays' in Madagascar, is found in the Indian Ocean Islands, tropical South and South-East Asia, Taiwan, northern Australia, Melanesia and Polynesia. Records for Tanzania and Mozambique remain unconfirmed. In Madagascar the bark and stems are used for making mats, baskets, fishtraps, and for constructing huts and roofs. It is considered a good alternative for rattan, all the more so as it will regrow after cutting. The leaves and stems are used in Madagascar to make a stimulating tea.

Ecology *Flagellaria guineensis* occurs from sea-level up to 1100 m altitude, in coastal forest, swampy forest, along rivers, in forest edges, thickets and waste places. It is a weed in rice fields in Nigeria and in tree plantations in East Africa, and has shown resistance to herbicides.

Management *Flagellaria guineensis* regrows after cutting and therefore sustainable harvesting is possible. In South Africa harvesting is a seasonal activity, most of it happening during the dry season (April–September) and most of the harvesters doing so very occasionally. The amount harvested varies widely from year to year.

Genetic resources and breeding *Flagellaria guineensis* is not under threat of genetic erosion.

Prospects *Flagellaria guineensis* will remain important for local use. It is easy to produce and can become an alternative for rattan, although it is of poorer quality. Its widespread medicinal use and the lack of knowledge on its chemical properties warrant phytochemical investigations.

Major references Burkill, 1994; Cawe, 1999; Matolweni & McLellan, 1997; Napper, 1971a; Neuwinger, 2000.

Other references Baldwin & Speese, 1957; Boiteau, Boiteau & Allorge-Boiteau, 1999; Brink, Jansen & Bosch, 2003; Edwards, 1997; Heine & Legère, 1995; Pakia & Cooke, 2003b; Pereira, Shackleton & Shackleton, 2006; Turpie, 2000; van Wyk & Gericke, 2000; Villiers, 1986.

Sources of illustration Akoègninou, van der Burg & van der Maesen, 2006.

Authors C.H. Bosch

FURCRAEA FOETIDA (L.) Haw.

Protologue Syn. pl. succ.: 73 (1812).

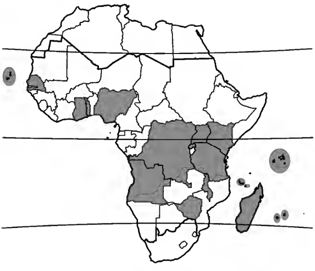
Family Agavaceae (APG: Asparagaceae)

Chromosome number $2n = 18, 34, 60$

Synonyms *Agave foetida* L. (1753), *Furcraea gigantea* Vent. (1793), *Furcraea tuberosa* Hassk. (1856).

Vernacular names Mauritius hemp, green aloe, giant cabuya (En). Chanvre de Maurice, fourcroya, aloès vert, aloès malgache, aloès créole (Fr). Piteira, piteira gigante, piteira amarela, cânhamo de Maurícia (Po).

Origin and geographic distribution *Furcraea foetida* is native to tropical America and its natural distribution extends from southern Mexico to the northern and eastern coast of South America and the south-eastern Antilles. It is widely planted and naturalized throughout the tropics. It has been grown commercially as a fibre plant in many regions, including India, Venezuela, Brazil, and St. Helena, and in Africa in Madagascar, Mauritius and South Africa. The plant was probably brought to Mauritius around 1790 and the fibre industry in Mauritius started around 1875. *Furcraea foetida* was brought to East Africa in the latter part of the 19th century, and it is still found as an escape throughout the region. In West Africa it can still be found around villages. The present distribution of *Furcraea foetida* in tropical Africa is unclear.



Furcraea foetida – planted and naturalized

Uses Mauritius hemp was historically used as a fibre plant, but this use is now increasingly rare. The fibre extracted from the leaf can be used to make twine, rope, cloth, tapestries, mats, hammocks and sacks. It can be mixed with other fibres such as sisal (*Agave sisalana* Perrine) and abaca (*Musa textilis* Née) for the production of medium grade cordage. Shorter fibres are suitable for brush making and upholstery. Old cordage and textile waste have been used for papermaking.

Furcraea foetida is widely planted as an ornamental plant in gardens, especially variegated varieties. It is also planted to prevent erosion, e.g. in Cape Verde. It is planted in hedges to form an effective barrier against humans and animals, for instance along railway tracks in India and Sri Lanka. In Sri Lanka it is also planted as a firebreak. The peduncles are used for the construction of huts and as poles for fencing. The leaves are used for washing laundry. Ash from burnt stems is used as fertilizer. The use of *Furcraea foetida* as fuel is reported from Cape Verde. Young plants are grazed by cattle. The species has been found to thrive on green roofs in Singapore, and is hence a possible candidate for planting of green roofs in the tropics and subtropics.

A leaf decoction is externally applied for the treatment of rheumatism and paralysis, and an alcoholic extract of the leaf is recommended as a diuretic in case of oedema. An infusion of the pith of the peduncle is also credited to treat oedema. The leaf sap is applied on purulent wounds, and used on the hair to make it glossy and to prevent hairs from falling out. On Rodrigues (Mauritius) a root decoction is often taken against fever and is considered refreshing. In Puerto Rico extracts from the roots are used as a blood-purifying tonic, and dried leaves are used to control swelling and to promote wound healing. In Brazil root decoctions are taken as a diuretic and against venereal diseases, slightly roasted leaf sections are applied on swellings and tumours, and the sap of roasted leaves is applied on ulcers and wounds.

A leaf decoction is used as an insecticide for domestic animals. In Madagascar the leaf sap is locally used as an insecticide against the rice pest *Trichispa sericea*. The leaves are also used as fish poison.

Production and international trade In the 1950s, the area under *Furcraea foetida* in Mauritius was about 7000 ha, of which about 5600 ha were wild. In the 1950s Mauritius produced about 1000 t of fibre annually, mainly used for production of sacks for sugar. The production has declined drastically since the 1950s, but no recent statistics are available concerning the production or trade of Mauritius hemp.

Properties The fibre content of fresh leaves is (1–)2–2.5(–3.8)%, which is lower than that of sisal or cantala (*Agave cantala* Roxb.). The ultimate fibre cells are (1–)1.3–3.8(–6.1) mm long and (14–)15–24(–42) µm wide, with thin walls and wide lumina. The longitudinal cell shape is cylindrical, with a polygonal cross-section. Fibre from Mauritius was found to contain 79.8% cellulose and 4.8% lignin. Fibre from various other parts of Africa contained 72–80% cellulose on a dry weight basis. Fibre from Indo-China, retted for 13 days, contained 63% cellulose, 18% pentosans, 12% lignin and 2% ash. Extracted fibres are 1–2 m long, creamy white and fairly lustrous when properly cleaned. The fibre is whiter, longer, finer, and softer than sisal fibre, but it is not as strong. Ropes made of *Furcraea foetida* fibre show similar resistance to seawater as sisal or abaca ropes, but are not considered suitable for marine cordage because of their lower strength. The fibre absorbs dyes fairly well.

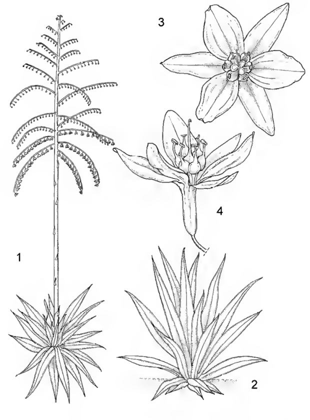
The leaves contain hecogenin (0.3% of the dry leaf weight), a steroidal sapogenin which can be used as a precursor in the partial synthesis of corticosteroids. They also contain tigogenin (0.2%), which is a contaminant of hecogenin.

Various anti-cancer compounds have been isolated from the leaves, the best-known among them furcreastatin, a steroidal saponin composed of hecogenin as the aglycone and a hexasaccharide containing D-galactose, L-rhamnose and four D-glucose residues. Furcreastatin has shown selective cytotoxicity on cells bearing a mutant tumour-inducing gene. Another steroidal saponin isolated from the leaf has shown in-vitro anti-inflammatory activity.

The leaves contain an irritant substance in the sap, so gloves should be worn when working with the plant. The sap is toxic to fish, guinea pigs and rabbits. In field experiments in Madagascar the leaf sap was found to reduce the level of infestation of rice by *Trichispa sericea*, but the effect was less than that of deltamethrin.

Adulterations and substitutes For rope-making, *Furcraea foetida* competes with sisal and abaca, which both possess clear advantages in terms of fibre strength and the availability of good machines for fibre extraction, and with synthetic products. For the production of sacks, jute (*Corchorus* spp.) and synthetic products are substitutes.

Description Robust, perennial herb with a short thick stem up to 1.5(–2) m tall, bearing about 50 densely crowded leaves in a rosette. Leaves broadly oblanceolate to lanceolate, up to 2.5 m × 20(–25) cm, apex ending in a reddish, flexible spine 5 mm long, margin with upcurved, robust, reddish spines 4–10 mm long and 1.5–6 cm apart, sometimes upper half or total margin spineless, tough-fibrous, glossy green, lower surface manifestly rough in the middle of the upper half, leaves fetid when bruised. Inflorescence a terminal panicle 6–13 m long (including peduncle); branches dividing several times; peduncle up to 10 m long. Flowers bisexual, pendulous, c. 4 cm long, greenish-white outside, white inside, fragrant; pedicel 5–10 mm long, bearing bracteoles in the axils of which bulbils are produced after flower dehiscence; perianth lobes 6, almost free, ellipsoid, 3 outer ones 25–30 mm × 10–15 mm, 3 inner ones 25–30 mm × 14–18 mm; stamens 6, filaments about 1 cm long, thickened in lower half, anthers 4–5 mm long; ovary inferior, 3-locular, style about 1 cm long, basally much thickened and trilobed, upper half filiform ending in small stigma. Fruit an ellipsoid-trigonous capsule, loculicidally 3-valved, with numerous but rarely produced seeds. Seeds flat, black.



Furcraea foetida – 1, habit of flowering plant; 2, habit of non-flowering plant; 3, flower in top view; 4, flower in side view.
Source: PROSEA

Other botanical information *Furcraea* is a poorly known tropical American genus with about 20 species of arid and semi-arid regions, formerly often classified in the larger family *Amaryllidaceae*. In taxonomic literature, various other spellings of the genus name exist, such as *Fourcroea*, *Fourcroya*, *Furcroea* and *Furcroya*. *Furcraea* resembles *Agave*, but can be distinguished by its flowers, which have a rotate white perianth with the segments barely united at the base, stamens shorter than the perianth, and filaments and style thickened below the middle.

In Mauritius *Furcraea foetida* fibre is mainly obtained from var. *willemettiana* Roem., which differs from the species type by its leaves, which are smaller, with short inconspicuous spines at the leaf tip, more sharply upwards curving marginal spines and a higher fibre content. The ornamental cultivar 'Mediopicta', with broad, spineless, variegated leaves, is considered particularly attractive.

Furcraea selloa K.Koch yields a fibre identical to that of *Furcraea foetida* and is also widely grown as an ornamental plant. It is native to Central America, where it is locally grown as a fibre plant. It is also grown in Réunion and Mauritius and it has been introduced into West Africa where it has naturalized. Like *Furcraea foetida* it contains the steroidal sapogenins hecogenin and tigogenin, and the steroidal saponin furcreastatin. Methanolic leaf extracts have shown activity against *Schistosoma mansoni*, the causal agent of bilharzia (schistosomiasis).

Growth and development *Furcraea foetida* is a monocarpic plant, dying after flowering, and has a life span of (5–)7–10(–20) years, in which about 200 leaves are produced. The leaves continue to elongate for about 5 months after bending away from the central spindle, resulting in longer leaves than those found in sisal, whose leaves do not elongate much after leaving the spindle. At flowering, long slender poles are produced, with many flowers which open few at a time over several weeks. Pollination is probably by moths and bees. The plants do not form suckers and they rarely set seed, but bulbils are formed in the inflorescence and they develop roots after they fall to the ground. Gravity is the only known natural dispersal method of bulbils, though the existence of isolated wild individuals suggest other means, such as fruit bats. *Furcraea foetida* uses the Crassulacean Acid Metabolism (CAM) photosynthetic pathway, fixing CO_2 during the night and incorporating it into carbohydrates during the day.

Ecology High temperatures and a semi-humid environment are needed for optimum growth. In Mauritius *Furcraea foetida* grows in areas with an average annual rainfall of about 1000 mm, with most precipitation from December to March. In Cape Verde it grows from sea level up to 1400 m altitude, while in Malawi good results were obtained up to 900 m altitude. *Furcraea foetida* is resistant to salt spray, short droughts, and temperatures down to −4°C or even −7°C. The plant grows in full sun as well as in partial shade. It grows well in any well-drained soil, appearing even on rocks, cliffs, and sometimes in tree crotches. Competition with grasses, weeds, shrubs, and trees may limit growth, and young plants are grazed and even uprooted by cattle. Mature plants are ignored by livestock. Mauritius hemp has become an invasive weed in some areas, for instance in Réunion and Mauritius.

Propagation and planting *Furcraea foetida* is propagated from bulbils, and may be raised in nurseries. A sample of 100 bulbils in Puerto Rico had an average weight of 2.7 g per bulbil, with individual weights ranging from 0.2 g to 16.3 g. Plants raised from these bulbils were 18 cm tall after 1 month, and were ready for planting out into the field in 1–2 months. In Mauritius *Furcraea foetida* is planted at a density of 3000–7500 plants/ha, preferably in double rows.

Management Young plants need weeding during the first months after planting, but require little care thereafter. Plantations in Mauritius are not weeded, but lanes between double rows of plants are cleared of vegetation just before harvest.

To control invasive *Furcraea foetida* plants, they are dug up or sprayed with 2,4-D or triclopyr. To prevent spreading, the inflorescence is cut before bulbils are formed.

Diseases and pests *Furcraea foetida* is a host of the Mexican sisal weevil (*Scyphophorus interstitialis*), a serious insect pest of sisal, which in tropical Africa has been recorded in Kenya and Tanzania.

Harvesting The first harvest usually takes place when the plants are 3–4 years old, and subsequent harvests every (8–)18–36 months thereafter. At each harvest 30–40 leaves are cut, and 5 leaves are left on the plant. Upon harvesting, the terminal spine and the butt of each leaf are trimmed, and the leaves are tied in bundles.

Yield In Mauritius in the 1950s, cultivated *Furcraea foetida* yielded on average 3.7 t/ha of fibre per cutting, from 150,000–200,000 leaves. Yields on certain estates reached 5 t/ha per cutting, and 2.5 t/ha per year. Yields from wild plants were about a third of those of cultivated plants.

Handling after harvest Fibre extraction is usually achieved by decortication and retting. Extraction is best undertaken immediately after harvest, as dried leaves are harder to decorticate. Decortication can be manual or mechanical, but available machines are less efficient than sisal decorticators. Decorticated fibres may be retted for 2 or more days to remove non-fibre matter. Adding soap during retting improves the colour of the fibre. The retted fibres are washed and sun-dried, and may then be brushed to soften them and add lustre. Finally the fibres are graded and baled.

Genetic resources In view of the wide distribution of *Furcraea foetida*, it seems not threatened with genetic erosion in the foreseeable future.

Breeding Breeding is rendered difficult due to the infrequent production of fertile seeds.

Prospects Mauritius hemp is clearly inferior to sisal and abaca for rope-making, both in terms of strength and in terms of the availability of machines and infrastructure for processing. It also faces competition from jute and synthetics. Hence, in terms of fibre production for rope-making or sacks, Mauritius hemp has little future. Unless its fibre can offer special qualities for specialty products such as clothing, paper pulp, or artisan work, *Furcraea foetida* will continue to diminish in importance, both in Mauritius and in the rest of the world. However, the anticancer potential of furcreastatin may create a new use of the species on the world stage. The low level of maintenance needed for *Furcraea foetida* makes it an attractive species for use as green fencing, for which it is already used in many countries. Its hardiness also makes it a potentially attractive plant for green roofs in the tropics and subtropics.

Major references Brotonegoro, 2003a; Burkill, 1985; Francis (Editor), 2004; Franck (Editor), 2005; Itabashi et al., 2000; Kirby, 1963; Marais & Coode, 1978; Rouillard & Guého, 2000; Vanden Berghen, 1988; Yokosuka et al., 2009.

Other references Agbedahunsi, Adesina & Elujoba, 1990; Akoègninou, van der Burg & van der Maesen, 2006; da Silva, Campos & Parente, 2006; d'Oliveira Feijão, 1963; El-Sayed et al., 2006; Getter & Rowe, 2008; Goulding, 1917; Goulding, 1937; Greenway, 1950; Gurib-Fakim et al., 1994; Hajaniaina, 2000; Huxley (Editor), 1992b; Johnson & Delgado, 2003; Lejeune, 1953; Mauersberger (Editor), 1954; Medina, 1959; Norman, 1937; Pascal, 2002; Roecklein & Leung (Editors), 1987; Simmons-Boyce et al., 2004.

Sources of illustration Brotonegoro, 2003a.

Authors G. Vaughan

Based on PROSEA 17: Fibre plants.

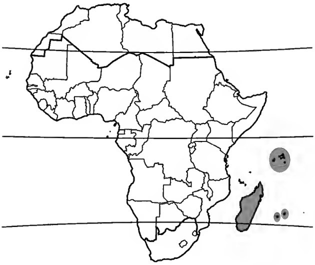
GAGNEBINA COMMERSONIANA (Baill.) R.Vig.

Protologue Notul. Syst. (Paris) 13: 346 (1948).

Family Mimosaceae (Leguminosae - Mimosoideae)

Origin and geographic distribution *Gagnebina commersoniana* is distributed in Madagascar, the Seychelles, Réunion and Mauritius. In Madagascar it occurs from the north, along the western side to the far south.

Uses In the western part of Madagascar, the bark fibres of *Gagnebina commersoniana* are used as an ingredient in the manufacture of the traditional 'Maintirano paper', a coarse paper that was originally used locally, but is now part of a much larger handicraft trade and is sold to tourists. The production process of the paper and its ingredients are poorly documented.



Gagnebina commersoniana – wild

Botany A small shrub up to 2 m tall; young branches pubescent, becoming glabrous with age. Leaves alternate, bipinnately compound with 3–16 pairs of pinnae; petiole 1–4.5 mm long, with a prominent gland at the apex on the upper side, rachis 0.5–6.5 cm long, both petiole and rachis grooved above and pubescent; pinna axis 5–17 mm long, ridged; leaflets 10–35 per pinna, opposite, sessile, up to 2 mm × 0.5 mm, asymmetrical, acute at apex, glabrous with ciliate margin. Inflorescence an axillary spike, solitary or paired, many-flowered; peduncle 5–10 mm long. Flowers bisexual, regular, 4-merous; calyx cup-shaped, c. 1 mm long, leathery; petals fused at base, 4.5–5 mm long, white; stamens 10, c. 2 mm long; ovary superior, stalked, 1-celled, style c. 3 mm long, slender. Fruit a narrowly oblong to oblong pod up to 3.5 cm × 0.5 cm, with long stipe, glabrous to short soft-hairy, indehiscent. Seed ovate to oblong, up to 3 mm × 1.5 mm, olive-brown.

Gagnebina comprises 4 species, all of them endemic to the Indian Ocean Islands.

A paper similar to that made from *Gagnebina* fibres is produced in the south of Madagascar. It is called 'Antaimoro paper' and is produced with the very fine fibres from *Gnidia linearis* (Leandri) Z.S.Rogers (synonym: *Lasiosiphon decaryi* Leandri). These fibres are also suitable for the production of textiles.

Ecology *Gagnebina commersoniana* occurs from sea-level up to 1000 m altitude, in thickets, woodland and disturbed vegetation on limestone, sand, gneiss and lateritic soil.

Genetic resources and breeding As *Gagnebina commersoniana* is widespread and not exploited in a large part of its range, it is unlikely to be threatened by genetic erosion.

Prospects *Gagnebina commersoniana* will continue to play a small role locally in the production of paper.

Major references du Puy et al., 2002; Schatz, 2001; Viguier, 1984.

Other references Boiteau, Boiteau & Allorge-Boiteau, 1999; Friedmann, 1994; ILDIS, 2005; Lewis & Guinet, 1986; Lewis et al., 2005; Luckow, 2002; Rogers, 2009.

Authors C.H. Bosch

GIRARDINIA BULLOSA (Steud.) Wedd.

Protologue Ann. Sci. Nat., Bot., sér. 4, 1: 181 (1854).

Family Urticaceae

Origin and geographic distribution *Girardinia bullosa* is distributed in eastern DR Congo, Rwanda, Burundi, Sudan, Ethiopia, Kenya, Uganda and Tanzania. It is sometimes cultivated.

Uses The bast fibre is made into string, sewing thread and textiles. In Ethiopia the bark is used for tying animals, making fences and making rope, and unspecified plant parts are used in veterinary medicine in case of retained afterbirth in cattle.

Botany Erect annual or short-lived perennial herb up to 3 m tall, monoecious or dioecious; stem up to 3.5 cm in diameter, unbranched or sparsely branched near the top, hollow; bark greenish to dark brown, pilose and densely covered with stinging hairs up to 8 mm long and 2 mm thick. Leaves alternate; stipules broadly lanceolate, fused for two-thirds of their length, 1.5–2.5 cm × 0.5–1 cm, hairy on the veins and ciliate; petiole 5–20 cm long, pilose and densely covered with stinging hairs up to 5 mm long; blade ovate to cordate, (10–)15–40 cm × (10–)15–35 cm, base truncate to cordate, apex acute to acuminate, margin doubly toothed, with on each side 10–18 teeth up to 2.5 cm wide, upper surface bullate, densely covered with stinging hairs 2–4 mm long, mineral concretions dot-like, lower surface densely pubescent, especially on the veins, and the largest veins also with stinging hairs up to 5 mm long, lateral veins in 5–7 pairs. Inflorescence an axillary panicle, unisexual; male inflorescence narrow, lax, up to 20 cm long, with flowers in clusters up to 1 cm in diameter; female inflorescence dense, with the ultimate branches forming small dichasia and with flowers single in bifurcations of the dichasia, 5–18 cm × c. 3 cm, densely pubescent and covered with stinging hairs. Flowers unisexual; male flowers on an up to 3 mm long pedicel, perianth 4(–5)-merous, c. 1.5 mm in diameter, each tepal with a dorsal horn-like appendage c. 0.5 mm long; female flowers sessile, up to 1.5 mm long, with 3 almost completely fused tepals and 1 free tepal up to 1.5 mm long, the middle of the fused tepals with a marked longitudinal keel, ovary superior, enclosed in the perianth, stigma filiform. Fruit an ovoid achene 2.5–4 mm in diameter, compressed, dark brown, usually warty.

Girardinia comprises 2 species distributed in mountain areas in the Old World tropics. It has the longest stinging hairs in the *Urticaceae*, but the sting seems less severe than that of some other genera, such as *Laportea*.

Ecology *Girardinia bullosa* occurs at 1750–3000 m altitude, in edges and clearings of rainforest, and in grassland along roads and near houses, often in abandoned fields.

Management *Girardinia bullosa* is propagated by seed. It does not resprout after cutting. After stems have been harvested in Burundi, the stinging hairs are removed and the entire bark is removed from the stem, after which the inner bark is separated in one piece and dried.

Genetic resources and breeding In view of its fairly wide distribution and the types of habitats in which it occurs, *Girardinia bullosa* does not seem in danger of genetic erosion.

Prospects *Girardinia bullosa* is a useful local source of fibre and tying material. No information is available on the fibre properties, however, making it difficult to assess its prospects. The presence of stinging hairs makes handling of the plant difficult.

Major references Friis, 1989b; Friis, 1989c; Hauman, 1948b; Nzigidahera, 2007.

Other references Baerts & Lehmann, 2009; Friis, 1981; Hanelt & Institute of Plant Genetics and Crop Plant Research (Editors), 2001; MacLachlan, 2002; Medina, 1959.

Authors M. Brink

GIRARDINIA DIVERSIFOLIA (Link) Friis

Protologue Kew Bull. 36(1): 145 (1981).

Family Urticaceae

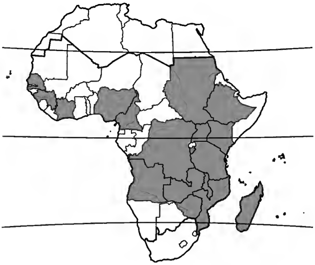
Chromosome number $2n = 20$

Synonyms *Girardinia erosa* Decne. (1844), *Girardinia heterophylla* (Vahl) Decne. (1844), *Girardinia condensata* (Steud.) Wedd. (1854).

Vernacular names Himalayan nettle, Nilgiri nettle, Nepalese nettle (En).

Origin and geographic distribution *Girardinia diversifolia* is widespread in tropical Africa, from Senegal eastward to southern Sudan and Ethiopia, and southward to Angola, Zimbabwe and South Africa, and also occurring in Madagascar. In Asia it occurs in Yemen and from India, Nepal and Sri Lanka to Indonesia, southern China and Taiwan. It is cultivated as a fibre plant in South India.

Uses The bast fibre is used in tropical Africa for making sewing thread, twine and rope. It



Girardinia diversifolia – wild

has been tried to make barkcloth from the fibre, but complete removal of the stinging hairs has proved difficult. In Kenya it has been grown in demonstration projects aiming at producing fibre, paper and insecticide from the plant. In India and Nepal the bast fibre is traditionally made into cordage for strings, ropes and fishing nets, and woven into cloth for bags, sacks, jackets, porters' headbands and mats. A more recent development in Nepal is the production of vests, shawls and a range of other articles aimed at tourist and export markets. The fibre is sometimes blended with ramie (*Boehmeria nivea* (L.) Gaudich.), cotton (*Gossypium* spp.) or wool. The woody stem parts can be used for papermaking.

The leaf and inflorescence are eaten as a vegetable. In Nepal the roasted and pickled seeds are eaten, and the plant is a source of livestock feed, bedding material, fuel and a blue dye. The seed can be used to make soap and other oil-based products.

In Rwanda *Girardinia diversifolia* is part of an antidote against snakebites, and in veterinary medicine a maceration of the leaves is used for treatment of theileriasis. In Kenya the root is boiled in goat's bone soup, which is drunk to gain strength. In Nepal leaf preparations are used for the treatment of headache, fever and swollen joints, and juice of the root is given in case of constipation. Ash of the plant is applied externally for the treatment of ringworm and eczema. In north-eastern India the seeds are used as fish poison.

Production and international trade There is some export of shawls and other woven products from Nepal to Europe, the United States and Japan.

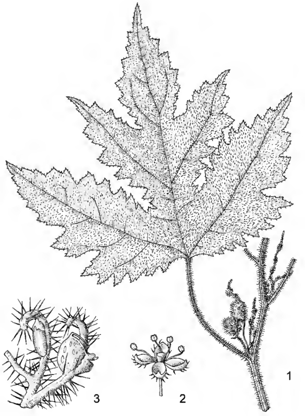
Properties The fibres are located in a wide ring in the outer part of the stem, not in bundles but as single fibre cells separated by parenchyma cells. In cross-section the fibre cells are polygonal or roundish in shape, with a wide lumen and relatively thin walls. They are (10–)200–400(–1300) mm long and (10–)30–160(–340) μm wide, with an average cell wall thickness of c. 5 μm.

The fibre content of the stem is 3.5–13.2% on a dry weight basis. In studies in Indo-China in the 1940s, the bark of *Girardinia diversifolia* yielded 61% fibre. Bark strips contained 16% moisture, 38% cellulose, 8% hemicelluloses, 8% lignin and 7% ash. After degumming, the fibre contained 11% moisture, 67% cellulose, 8% hemicelluloses, 4% lignin and 3% ash. Indian fibre has been recorded as containing 7% moisture, 90% cellulose and 1.5% ash.

The bast fibre is of good quality: long, strong, smooth and lustrous. The tensile strength of Nepalese fibre was 180–550 N/mm^2, with the lowest values at the tip and the highest values at the base of the stem. The modulus of elasticity was 5.8–22.5 GPa, without differences between segments of the stem. The fibre is comparable to ramie fibre, but contains more gums, which, however, are removed easily. The fibre can be spun into long filaments.

The aerial parts contain alkaloids, acetylcholine, histamine and 5-hydroxytryplamine. The seed contains 10–12% oil. The sting of the hairs is sharply felt, and is said to last from only a few minutes to a few hours.

Description Erect annual or short-lived perennial herb up to 1.5(–3) m tall, monoecious or dioecious; stem up to 1(–2) cm in diameter, sparsely branched, hollow; bark often furrowed, greenish to dark brown, densely covered with stinging hairs 7–9 mm long and with short stiff hairs. Leaves alternate; stipules linear-lanceolate, fused for over four-fifths of their length, hairy outside; petiole 3–15(–24) cm long, pubescent to pilose, densely covered with stinging hairs and stiff hairs; blade elliptical to ovate in outline but extremely variously lobed or divided, 6–20(–25) cm × 3.5–18(–25) cm, base cuneate, truncate or cordate, apex acute or acuminate, margin toothed, upper surface not bullate, with scattered stiff hairs and stinging hairs up to 7 mm long, and dot-like mineral concretions, lower surface with stinging hairs on the larger veins and pubescence on fine reticulation of veins, lateral veins in 3–6 pairs. Inflorescence unisexual, cylindri-



Girardinia diversifolia – 1, part of flowering stem; 2, male flower; 3, part of infructescence. Redrawn and adapted by Achmad Satiri Nurhaman

cal; male inflorescence a narrow, spicate panicle up to 10 cm long, with flowers in dense clusters, peduncle up to 2 cm long, with stinging hairs; female inflorescence a dense cymose dichasium 2–3 cm long at anthesis, elongating to 10–15 cm long in fruit, densely covered with stinging hairs. Flowers unisexual; male flowers on a 1 mm long pedicel, perianth 4–5-merous, c. 1 mm in diameter, tepals without dorsal appendages; female flowers sessile, perianth 1.5–2 mm long, with 3 almost completely fused tepals and the fourth one usually lacking, ovary superior, enclosed in the perianth, stigma filiform. Fruit an ovoid to subcordate achene 3–4 mm in diameter, compressed, brown.

Other botanical information *Girardinia* comprises 2 species distributed in mountain areas in the Old World tropics. It has the longest stinging hairs in the *Urticaceae*, but the sting seems less severe than that of some other genera, such as *Laportea*. *Girardinia diversifolia* is a highly polymorphic species, with particularly much variation in leaf morphology and in the shape and size of the female inflorescence.

Ecology *Girardinia diversifolia* occurs at (300–)1000–2500 m altitude in rainforest and dry forest, especially in clearings, natural glades and along edges, also in woodland, savanna, cultivated areas and moist rocky locations. It prefers partial shade. In Madagascar it is a weed of cultivated areas.

Propagation and planting *Girardinia diversifolia* can be propagated by seed and vegetatively by offsets.

Handling after harvest After harvesting, the leaves and stinging hairs are removed from the stem, and the bark is stripped off. In Cameroon the stinging hairs are removed with a cloth before the fibre is extracted from the stem.

To extract the fibre in Asia, the bark is boiled for 3–4 hours in an alkaline solution made from wood ash, before it is beaten and washed until it is clean, after which it is rubbed with mica-rich clay, rice husk or maize flour, and dried in the sun. Rubbing with clay seems to have the combined effect of bleaching and lubricating the fibre. Alternatively, the fibre may be extracted by stripping the bark off the stem, after which it is washed or scraped until the fibre is clean, or the stripped-off bark is dried, and the fibre is freed by pounding, after which it is boiled with an alkaline solution, and then washed until it is clean.

Genetic resources In view of its extensive distribution and wide range of habitats, *Girardinia diversifolia* is not threatened by genetic erosion.

Prospects *Girardinia diversifolia* yields fibre of good quality, similar to ramie fibre in many respects. Therefore, the prospects for increased use of the plant are good. The fibre is especially suitable for the production of textiles, for which the same techniques can be applied as those used for ramie. The fibres with their large lumina and thus low density can also be used as renewable raw material in composites. A major disadvantage of *Girardinia diversifolia* compared to ramie is the presence of stinging hairs on all plant parts, which makes handling unpleasant.

Major references Brink, Jansen & Bosch, 2003; Burkill, 2000; Dreyer & Edom, 2005; Friis, 1981; Friis, 1989c; Jacques-Félix & Rabéchault, 1948; Jarman, 1998; Kirby, 1963; Sethmann, 2004; Sethmann & Dreyling, 2001.

Other references Barakoti & Shrestha, 2008; Boiteau, Boiteau & Allorge-Boiteau, 1999; CSIR, 1956; Deokota & Chhetri, 2009; Desouter, 1991; Dunsmore, 1998; Friis, 1989b;

Friis & Immelman, 2001; Hauman, 1948b; Ichikawa, 1987; Leandri, 1965; Letouzey, 1968; Manandhar, 1995; Mauersberger (Editor), 1954; Medina, 1959; PFAF, 1996–2008; Saxena, Tangri & Bhargava, 1966; Shrestha, 1997; Singh & Shrestha, 1988; Westphal, 1975.

Sources of illustration Friis, 1989c.

Authors M. Brink

GNIDIA DAPHNIFOLIA L.f.

Protologue Suppl. pl.: 225 (1782).

Family Thymelaeaceae

Synonyms *Dais madagascariensis* Lam. (1786), *Lasiosiphon pubescens* (Lam.) Decne (1841), *Lasiosiphon baroni* Baker (1890).

Origin and geographic distribution *Gnidia daphnifolia* is endemic to Madagascar.

Uses The bast fibre is used for cordage. Like that of many other species in Madagascar, the bark was formerly beaten on a mallet to obtain a kind of felt used for cloth. As technology evolved, fibres were extracted by crushing the bark, after which they were combed or scutched, making them suitable for spinning and weaving. *Gnidia daphnifolia* is also one of the species of which the bark fibre is locally made into 'Antaimoro paper', a paper of excellent quality made into articles such as stationary, envelopes, cards, notebooks, photo albums, lampshades and gift bags.

Properties The bast fibre is fine and silky.

Botany Shrub up to 2 m tall; branches glabrescent, outer bark reddish brown, striate. Leaves with petiole up to 5 mm long; stipules absent; blade obovate-lanceolate to oblong, 20–70 mm × 8–20 mm, base attenuate or slightly cuneate, apex obtuse, sparsely hairy or glabrous. Inflorescence an axillary or terminal head 1.5–2 cm in diameter, 15–20-flowered; peduncle 1–5 cm long, hairy, greyish green; involucral bracts often fused at the base, acuminate, hairy. Flowers bisexual, regular, 5-merous, red, orange or yellow; calyx tube cylindrical, 12–18 mm long, lobes ovate to oblong or obtuse, 2–3 mm long; petals inserted in the throat of the calyx tube, alternate with calyx lobes, scale-like, ovate-oblong, up to 2 mm long, membranous; stamens 10, in 2 whorls of unequal length, the upper whorl inserted in the throat of the calyx tube, the other one inserted lower; ovary superior, 1-locular, hairy or glabrous, style filiform. Fruit oblong, 4–5 mm long, enclosed by the persistent base of the calyx tube, covered with long stiff whitish hairs.

Gnidia comprises about 140 species, mainly distributed in tropical Africa, with 20 species endemic to Madagascar, but it also extends into Arabia, western India and Sri Lanka. The bast fibre of *Gnidia danguyana* Leandri, a shrub endemic to Madagascar, is used for the same purposes as that of *Gnidia daphnifolia*.

Ecology *Gnidia daphnifolia* occurs in sandy and rocky locations.

Genetic resources and breeding It is unclear whether *Gnidia daphnifolia* is threatened by genetic erosion.

Prospects Little information is available on *Gnidia daphnifolia* and its fibre properties. Its use in the niche market for high-quality 'Antaimoro paper' may increase with increasing tourism to Madagascar.

Major references Boiteau, Boiteau & Allorge-Boiteau, 1999; Leandri, 1950; Schatz, undated.

Other references Rogers, 2006; Rogers & Spencer, 2006.

Authors M. Brink

GNIDIA GLAUCA (Fresen.) Gilg

Protologue Bot. Jahrb. Syst. 19: 265 (1894).

Family Thymelaeaceae

Synonyms *Lasiosiphon glaucus* Fresen. (1838), *Gnidia eriocephala* Meisn. (1841).

Vernacular names Fish-poison bush (En).

Origin and geographic distribution *Gnidia glauca* is widely distributed in tropical Africa, from Nigeria eastward to Sudan and Ethiopia and southward to Malawi and Zambia. It also occurs in southern India and in Sri Lanka.

Uses Fibre from the bark is made into rope and thread. The bark is used for lighting fire. A decoction of the boiled root is drunk in East Africa for treatment of indigestion. In Ethiopia root powder mixed with skimmed milk is taken orally for seven days for treatment of rabies. The bark is made into arrow poison in Kenya: it is boiled in water for several hours and the residue is smeared on arrow tips. In India the bark and leaf are used for treatment of blisters, swellings and contusions, leaf extracts are used as insecticide and the stem, bark and leaf as a fish poison. In Sri Lanka the ground whole plant is used as an insecticide and piscicide.

Properties The bark fibre is strong and said to be poisonous. An alcohol extract of the root showed strong in-vivo inhibitory activity against P-388 leukaemia in mice. Extracts of the fresh bark exhibited larvicidal activity against *Aedes aegypti*. Leaf extracts exhibited some insecticidal activity against *Aedes aegypti*, *Anopheles stephensi*, *Culex pipiens pallens*, *Culex quinquefasciatus*, *Plutella xylostella* and *Spodoptera litura*, and fungicidal activity against *Venturia inaequalis*. Aqueous extracts of the leaf showed some antifeedant activity against the armyworm *Helicoverpa armigera*. In Sri Lanka the leaf and twig were found to contain alkaloids.

Botany Large, much-branched shrub up to 6 m tall or small tree up to 15(–24) m tall; outer bark grey, brown or blackish, smooth to wrinkled; inner bark fibrous, pale yellow, fragrant. Leaves alternate, clustered in the upper parts of branches, simple and entire, almost sessile or with petiole 1–3 mm long; stipules absent; blade narrowly elliptical to obovate, (20–)25–65(–85) mm × 6–26 mm, gradually narrowed to the base, rigid, hairy or glabrous, glaucous, midvein prominent beneath. Inflorescence a dense terminal head 2–5 cm in diameter, 20–70-flowered; peduncle widening towards the top, hairy; bracts 6–12(–15), elliptical to ovate, 10–15 mm × 4–10 mm, slightly leathery, softly hairy on both sides, cream-coloured or salmon-pink, persistent. Flowers bisexual, regular, (4–)5-merous, orange or golden yellow, fading to brown; pedicel 1–2.5 mm long, hairy; calyx tube cylindrical, 9–14 mm long, without articulation, the upper part softly hairy, the lower part with dense tufts of silky hairs 2–4 mm long, lobes imbricate, ovate, entire or lobed, 2.5–5 mm × 1.5–2 mm, hairy outside; petals inserted in the throat of the calyx tube, elliptical or spathulate, 1–2 mm long, entire, emarginate or lobed, membranous or fleshy; stamens (8–)10, in 2 whorls of unequal length, inserted in the throat of the calyx tube, upper whorl slightly exserted; ovary superior, 1-locular, hairy, style filiform, 6–10 mm long. Fruit enclosed by the persistent base of the calyx tube. Seeds 3–4 mm × 1.5–2 mm, black.

In Kenya *Gnidia glauca* flowers in February – March and May–July.

Gnidia comprises about 140 species, mainly distributed in tropical Africa, with 20 species endemic to Madagascar, but it also extends into Arabia, western India and Sri Lanka. *Gnidia glauca* var. *glauca* is distributed in tropical Africa and southern India, whereas *Gnidia glauca* var. *insularis* (Gardner) C.C.Towns. is endemic to Sri Lanka. The latter has twigs and leaves more or less densely covered with persistent long appressed hairs, whereas those of the former are glabrescent.

Ecology *Gnidia glauca* occurs at 950–3300 m altitude, in forest margins and associated bushland or wooded grassland, on rocky grassy slopes and around stream beds. In East Africa it is sometimes locally dominant in secondary forest.

Genetic resources and breeding In view of its wide distribution and local abundance, *Gnidia glauca* is not threatened by genetic erosion.

Prospects *Gnidia glauca* yields a strong fibre suitable for cordage, but detailed information on the fibre properties is unavailable, making it difficult to assess its prospects. The plant has toxic properties and is used as an insecticide and piscicide. Research on its phytochemistry and the risks of its use for human health and the environment seems warranted.

Major references Beentje, 1994b; Coates Palgrave, 1983; Greenway, 1950; Peterson, 1978; Peterson, 2006.

Other references Amarajeewa, Mudalige & Kumar, 2007; Bussmann, 2006; Eggeling & Dale, 1951; Kokwaro, 1993; Ohgashi et al., 1991; Peterson, 1976; Sakthivadivel & Daniel, 2008; Sommerlatte & Sommerlatte, 1990; Sundararajan & Kumuthakalavalli, 2001; Teklehaymanot & Giday, 2007.

Authors M. Brink

GNIDIA LAMPRANTHA Gilg

Protologue Bot. Jahrb. Syst. 19: 264 (1894).

Family Thymelaeaceae

Synonyms *Lasiosiphon lampranthus* (Gilg) H.Pearson (1910).

Origin and geographic distribution *Gnidia lamprantha* is distributed in Sudan, Ethiopia, Kenya, Uganda and Tanzania.

Uses Fibre from the bark is used for making cord and rope.

Properties The bark fibre is white. *Gnidia lamprantha* contains the diterpenes gnicidin, gnididin, gniditrin, which have shown antitumour activity. However, gnicidin is also known to have inflammatory and tumour-promoting activity.

Botany Much-branched shrub or small tree up to 3(–5) m tall, unbranched at the base, branched above; branches densely hairy. Leaves alternate, simple and entire, almost sessile; stipules absent; blade lanceolate to elliptical or oblanceolate, 20–50 mm × 5–12 mm, base obtuse, apex acute or shortly apiculate, hairy or glabrous, pale green or glaucous. Inflorescence a dense terminal head, 40–70-flowered; peduncle short; bracts 6–10, ovate, 6–12 mm × 4–9 mm, densely hairy on both sides, pale yellow, persistent. Flowers bisexual, regular, 5-merous, yellow to orange-yellow; pedicel short, with long stiff hairs; calyx tube cylindrical, 8–12 mm long, without distinct articulation, the lower part with dense tufts of silky hairs, the upper part densely yellow-hairy, lobes imbricate, ovate or elliptical, 3–4 mm × 1.5–3 mm, apex obtuse, hairy beneath, pale green to yellow; petals inserted in the throat of the calyx tube, filiform, linear or linear-spathulate, 1–1.5 mm long, membranous; stamens 10, in 2 whorls of unequal length, inserted in the throat of the calyx tube, almost sessile, upper whorl exserted; ovary superior, 1-locular, hairy at top, style filiform, 4–8 mm long. Fruit dry, small, enclosed by the persistent base of the calyx tube. Seeds 2.5–3 mm × 1–1.5 mm.

In Kenya *Gnidia lamprantha* flowers in August–February.

Gnidia comprises about 140 species, mainly distributed in tropical Africa, with 20 species endemic to Madagascar, but it also extends into Arabia, western India and Sri Lanka.

Ecology *Gnidia lamprantha* occurs at 1050–2300 m altitude, in grassland and bushland, often in rocky locations.

Genetic resources and breeding *Gnidia lamprantha* is fairly widely distributed and does not seem in danger of genetic erosion.

Prospects *Gnidia lamprantha* yields a fibre locally used for cordage, but detailed information on the fibre properties is unavailable. The plant contains compounds with anti-tumour properties, but toxicity has also been reported, and more research on these compounds is necessary to assess their potential.

Major references Beentje, 1994b; Peterson, 1978; Peterson, 2000.

Other references Daniel, 2006; Eggeling & Dale, 1951; Greenway, 1950; Kupchan et al., 1975; Rizk, 1991.

Authors M. Brink

GNIDIA LATIFOLIA (Oliv.) Gilg

Protologue Engl., Pflanzenw. Ost-Afrikas C: 283 (1895).

Family Thymelaeaceae

Synonyms *Lasiosiphon latifolius* (Oliv.) Brenan (1949).

Vernacular names Mwata, mnunguwa-mwitu, kinyunywa (Sw).

Origin and geographic distribution *Gnidia latifolia* is distributed in Somalia, Kenya and Tanzania, and possibly Ethiopia.

Uses The bark yields a strong fibre that is made into rope. Stems and branches are used for building and fencing in Kenya, because they are never attacked by termites. Plant material is also placed around seedlings to keep termites away, and plant parts are burned to produce pesticidal smoke. An extract of the bark or root is drunk as a purgative. The young leaves are said to be used for making poison.

Properties The diterpenoid esters gnidilatin 20-palmitate and gnidilatidin 20-palmitate, isolated from the stem wood and bark, have shown strong in-vivo inhibitory activity against P-388 leukaemia in mice. Other compounds isolated from the stem wood and bark are gnidilatin, showing moderate antileukaemic activity, gnidilatidin, and the furanosesquiterpene gnididione. Gnidilatin and gnidilatidin have shown piscicidal activity. The leaf and stem are poisonous, and grass underneath *Gnidia latifolia* is not eaten by livestock.

Botany Large, much-branched shrub up to 5 m tall; branches hairy when young, later glabrous. Leaves alternate, simple and entire; stipules absent; petiole 1–2 mm long; blade oblong to oblanceolate, 18–55 mm × 5–14 mm, base cuneate, apex obtuse, with scattered hairs or glabrous above, sparsely appressed hairy beneath. Inflorescence a head, 5–12(–15)-flowered; peduncle 14–30 mm long, leafless, sparsely hairy, glabrescent; bracts 4–6, oblong or elliptical, 10–16 mm × 4–6 mm, ciliate, finely silvery hairy outside, sparsely hairy or glabrous inside, caducous. Flowers bisexual, regular, 5-merous, yellow or orange; pedicel c. 2 mm long, hairy; calyx tube cylindrical, 13–16 mm long, articulate above the ovary, densely hairy above the articulation, with 3–4 mm long white hairs below the articulation, lobes imbricate, oblong to elliptical, 3–5 mm × 2–3 mm, apex rounded, hairy beneath; petals 8, inserted in the throat of the calyx tube, linear, up to 0.5 mm long; stamens 10, in 2 whorls of unequal length, inserted in the throat of the calyx tube, upper whorl slightly exserted; ovary superior, shortly stalked, 1-locular, upper part hairy, style filiform, 6–8 mm long. Fruit dry, small, enclosed by the persistent base of the calyx tube. Seeds 4–4.5 mm × c. 2 mm.

In Kenya *Gnidia latifolia* flowers throughout the year.

Gnidia comprises about 140 species, mainly distributed in tropical Africa, with 20 species endemic to Madagascar, but it also extends into Arabia, western India and Sri Lanka.

Ecology *Gnidia latifolia* occurs from sea-level up to 2000 m altitude, in deciduous and evergreen bushland and wooded grassland.

Genetic resources and breeding *Gnidia latifolia* is fairly widely distributed and does not seem in danger of genetic erosion.

Prospects *Gnidia latifolia* is a useful local source of fibre and termite-resistant material for building and fencing. The fibre is said to be strong, but further information on the fibre properties is unavailable. The plant contains compounds with antileukaemic activity, but it has also been recorded to be toxic, so more research on its phytochemistry seems useful.

Major references Beentje, 1994b; Kupchan et al., 1976b; Peterson, 1978; Peterson, 2000.

Other references Cuccuini, 1993; Kokwaro, 1993; Kupchan et al., 1977; Macharia, 2004; Macharia & Ekaya, 2005; Medley & Kalibo, 2007; Neuwinger, 2000; Weiss, 1979.

Authors M. Brink

GNIDIA SUBCORDATA Meisn.

Protologue Linnaea 14: 430 (1840).

Family Thymelaeaceae

Synonyms *Englerodaphne subcordata* (Meisn.) Engl. (1921).

Vernacular names Smooth fibre-bush (En).

Origin and geographic distribution *Gnidia subcordata* is distributed in Sudan, Kenya, Uganda, Tanzania and South Africa.

Uses The bark yields a strong fibre, which is made into rope. In Kenya the woody parts are used for laths. The fruit is said to be poisonous, but has been recorded to be eaten in South Africa.

Properties In research to find tumour inhibitors from plant sources, an ethanol extract of unspecified plant parts showed significant in-vivo activity against P-388 leukaemia in mice, due to the presence of the diterpenoid esters gnidimacrin and gnidimacrin 20-palmitate.

Botany Much-branched shrub up to 4 m tall (rarely a small tree); branches slender, glabrous; outer bark smooth, dull or purplish grey. Leaves opposite, simple and entire; stipules absent; petiole 0.5–1 mm long; blade ovate or suborbicular, 10–25(–40) mm × 5–15(–18) mm, base rounded or truncate, sometimes subcordate, apex acute, rounded or truncate, membranous, glabrous or with occasional hairs along the midrib beneath, green above, glaucous-green beneath. Inflorescence a terminal fascicle, (1–)4–6(–8)-flowered; bracts absent. Flowers bisexual, regular, 4-merous, greenish white, white or cream; pedicel short; calyx tube cylindrical, 9–14 mm long, constricted below the middle, glabrous or with few silky hairs, lobes imbricate, oblong, spreading during flowering, 3.5–5 mm × c. 2 mm, glabrous or sometimes with a few hairs; petals 8, inserted in the throat of the calyx tube, linear-spathulate, 1–3 mm × c. 1 mm, apex emarginate or toothed, somewhat fleshy; stamens 8, in 2 whorls of unequal length, inserted in the throat of the calyx tube, almost sessile; ovary superior, shortly stalked, 1-locular, densely hairy, style filiform, 4–6 mm long. Fruit dry, small, enclosed by the persistent base of the calyx tube.

In Kenya *Gnidia subcordata* flowers throughout the year.

Gnidia comprises about 140 species, mainly distributed in tropical Africa, with 20 species endemic to Madagascar, but it also extends into Arabia, western India and Sri Lanka.

Ecology *Gnidia subcordata* occurs at 1400–2400 m altitude, in dry evergreen forest and associated bushland, *Acacia* woodland and wooded grassland.

Genetic resources and breeding In view of its fairly wide distribution and range of habitats, *Gnidia subcordata* is not threatened by genetic erosion.

Prospects *Gnidia subcordata* yields a strong fibre suitable for cordage, but detailed information on the fibre properties is unavailable, making it difficult to assess its prospects. The plant contains compounds with antileukaemic properties, but toxicity has also been reported, so more research on its phytochemistry seems useful.

Major references Beentje, 1994b; Coates Palgrave, 1983; Peterson, 1978.

Other references Brokensha & Riley, 1986; Kupchan et al., 1976a.

Authors M. Brink

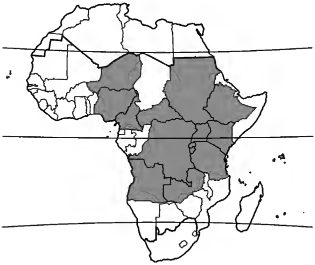
GOMPHOCARPUS SEMILUNATUS A.Rich

Protologue Tent. fl. abyss. 2: 39 (1851).

Family Asclepiadaceae (APG: Apocynaceae)

Synonyms *Asclepias semilunata* (A.Rich.) N.E.Br. (1902).

Origin and geographic distribution *Gom-*



Gomphocarpus semilunatus – wild

phocarpus semilunatus is distributed from Nigeria eastward to Ethiopia and from there southward through East Africa to southern DR Congo, Zambia and Angola.

Uses Fibre from the inner bark of *Gomphocarpus semilunatus* is used for making fishing nets. After processing, it can be spun with cotton, and it is used to make snares and waistbands. The seed floss is used for stuffing in Uganda.

In traditional medicine in Rwanda a decoction of the whole plant is taken for the treatment of malaria, fever and madness and an extract of the aerial parts is drunk as an aphrodisiac. In Burundi a leaf infusion or juice from the leaves is drunk as an emetic and a leaf decoction is used as wash to serve as a tonic for pregnant women. In Kivu (DR Congo) the whole plant is made into a paste that is rubbed on rheumatic limbs. In Kenya a warm decoction from the roots is drunk to expel intestinal worms and leaves are used as a cure for fever, congested nose and epilepsy. In Uganda the bark is chewed or root preparations are taken to end vomiting, and the whole plant is eaten with groundnut-paste as a cure for hypertension. Drops from crushed leaves are instilled in the nose as a cure for migraine. In veterinary medicine a leaf infusion is instilled to induce uterus contractions in cows.

Properties The bast fibre strands are 1–1.5 m long, white to pale brown, lustrous and fairly strong. They are considered suitable for coarse textiles. The fibre strands are easily broken down ('cottonized') into the ultimate fibres, which have about the same length and width as cotton but lack a natural twist, which might cause trouble in spinning with machinery designed for cotton.

Botany Shrubby perennial herb, 1–2.5 m tall, stems stout, erect, frequently unbranched, densely hairy with spreading white hairs in the upper part, woody at base, with taproot. Leaves opposite or in whorls of 4, simple and entire; petiole 2–6 mm long; blade linear to narrowly linear-lanceolate, 8–12 cm × 0.5–1.5 cm, base cuneate or truncate, apex acute or attenuate, sparsely hairy with soft white hairs particularly on midrib and margins. Inflorescence an extra-axillary, nodding umbel, 5–9-flowered; peduncle 1–4 cm long; bracts deciduous. Flowers bisexual, regular, 5-merous; pedicel 1.5–2 cm long; sepals lanceolate, 5–9 mm long, attenuate; corolla reflexed, white or pink, lobes ovate, 7–9 mm × 4–5 mm, subacute; corona lobes attached c. 1 mm above base of staminal column, laterally compressed, 3 mm × 2.5–3 mm, shorter than the column; anthers with c. 2 mm long wings; ovary superior, carpels 2, free, stigma head flat. Fruit a pair of upright follicles, each follicle subglobose, 7 cm × 5 cm, not beaked, inflated, balloon-like, with filiform processes c. 1 cm long, many-seeded. Seeds ovate with one convex and one concave face, c. 3.5 mm × c. 1.5 mm, warted, hairs c. 3 cm long.

Gomphocarpus comprises about 20 species and is distributed in tropical Africa and Peninsular Arabia. *Gomphocarpus physocarpus* E.Mey. is native to Mozambique, Botswana, South Africa and Swaziland. It can be distinguished from *Gomphocarpus semilunatus* by a much shorter calyx and by the shape of the corona. It has been introduced elsewhere and is found in seasonally dry and disturbed areas of Kenya, Uganda, Tanzania and Zambia. In several Indian Ocean islands an introduced *Gomphocarpus* species, probably *Gomphocarpus physocarpus*, is used medicinally. In Australia the species hybridizes with *Gomphocarpus fruticosus* (L.) W.Aiton and hybridization is probably taking place in East Africa as well. In South Africa the powdered leaves are sniffed as a cure for headache, tuberculosis and as an emetic. The latex is applied to warts. The fibre use that has been reported for the species should be attributed to *Gomphocarpus semilunatus*.

Ecology *Gomphocarpus semilunatus* occurs at 300–2600 m altitude in seasonally flooded grasslands and waste places, frequently in large numbers.

Management In Rwanda in the 1950s the stems of plants collected from the wild yielded 0.7% fibre after 10 days of retting. *Gomphocar-*

pus semilunatus has been cultivated in East Africa, where it proved very susceptible to insect pests. Fibre yields in East Africa have been estimated at 280–400 kg/ha.

Genetic resources and breeding *Gomphocarpus semilunatus* is widespread and not heavily exploited so no threats are foreseen.

Prospects The properties of the fibre produced by *Gomphocarpus semilunatus* is such that it could be used to produce soft fabrics. As a first step to verify the feasibility of commercial exploitation, research into domestication and management are needed.

Major references Burkill, 1985; Goulding, 1937; Goyder & Nicholas, 2001; Greenway, 1950; Lejeune, 1953.

Other references Chagnon, 1984; Chifundera, 2001; Fowler, 2007; Geissler et al., 2002; Hamill et al., 2003; Neuwinger, 2000; Peyre de Fabrègues & Lebrun, 1976; Tabuti, Lye & Dhillion, 2003; Vlietinck et al., 1995.

Authors C.H. Bosch

GOSSYPIUM ARBOREUM L.

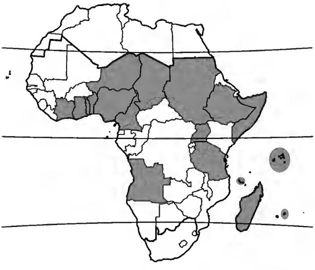
Protologue Sp. pl. 2: 693 (1753).

Family Malvaceae

Chromosome number 2*n* = 26

Vernacular names Cotton, tree cotton (En). Coton, cotonnier, coton arborescent, cotonnier rouge (Fr). Algodoeiro, algodoeiro arbóreo (Po). Pamba (Sw).

Origin and geographic distribution *Gossypium arboreum* is only known in cultivation and its origin is uncertain. It may have developed from *Gossypium herbaceum* L., though molecular comparisons support the hypothesis that *Gossypium arboreum* and *Gossypium herbaceum* diverged from a common ancestor. *Gossypium arboreum* has been cultivated in Asia for many centuries. It is still found there, but has mostly been replaced by *Gossypium hirsutum* L. From Asia *Gossypium arboreum* was brought to Sudan, and from there it spread to West Africa. Nowadays it is cultivated mainly in the drier parts of India and Pakistan, and sometimes in tropical Africa, where it has occasionally naturalized. In tropical Africa it is common in yards and abandoned dwelling sites.



Gossypium arboreum – planted and naturalized

In this article the word ‘cotton’ refers to information referring to all 4 cultivated *Gossypium* species (*Gossypium arboreum*, *Gossypium barbadense* L., *Gossypium herbaceum* and *Gossypium hirsutum*); where information refers to *Gossypium arboreum* only, this is stated explicitly.

Uses Cotton is the most important group of fibre plants in the world. The oldest evidence of the use of cotton as a fibre plant in the Old World was found in Pakistan and probably refers to *Gossypium arboreum*; it is estimated to date from about 2300 BC. The main fibres of cotton plants are the longer seed hairs (‘lint’), used for making yarn to be woven into textile fabrics, alone or in combination with other plant, animal or synthetic fibres. Cotton lint is also made into other products including sewing thread, cordage and fishing nets. Cotton textile cuttings and rags serve in the paper industry for the production of the best writing, book and drawing paper. Short fibres (‘fuzz’ or ‘linters’) are processed into a range of products, including papers, twine, automobile upholstery, explosives, plastics and photographic film. Linter pulp is made into various types of paper, depending on its grade. Linters have also been used for the production of cellulose acetate and viscose. Cotton stalks are processed into paper and paperboard, for instance in China, and into cement-bonded particle board.

Oil obtained from cotton seed is industrially used in a range of products, including margarine, mayonnaise, salad and cooking oils, salad dressing and shortening. It is also made into soap, cosmetics, lubricants, sulphonated oils and protective coatings. Locally it serves for cooking and frying. Blends of cotton-oil biodiesel and diesel fuel can be used in conventional diesel engines without any major changes. The seed cake remaining after oil extraction is an important protein concentrate for livestock. Low-grade cake is used as manure. The whole seed can be fed to ruminants, which are less sensitive to the toxic gossypol in the seed than non-ruminants, or is applied as manure. Hulls are a low-grade roughage for livestock or serve as bedding or fuel. Leftover bolls, leaves and thin twigs are grazed by ruminants. Dry stalks serve as household fuel.

Gossypium arboreum is much less important in tropical Africa than *Gossypium hirsutum* and *Gossypium barbadense*, and seems to be used for medicinal purposes and as a fetish plant more than as a fibre plant. For instance in Niger, where *Gossypium arboreum* is now only occasionally found in gardens, farmers remarked that in the past it was grown for fibre production, while nowadays it is only used for medicinal purposes. In West Africa the fibre of *Gossypium arboreum* has been made into fine cloth worn by chiefs and used for wound dressing. In Cameroon the fibre is made into cloth used for dowries and in burials. In Madagascar it is also woven into cloth. In Nigeria the seeds are made into fermented cakes, and the seed oil is used for cooking. In Kordofan (Sudan) the leaves are browsed by cattle. The flowers yield a yellow dye. Crushed with lime juice they give a red dye used for colouring cotton thread and goat leather. In Benin the flowers are used for making a black dye for leather, and the plant is sometimes grown specifically for this purpose.

Gossypium arboreum is widely used in African traditional medicine. The root is considered an emmenagogue and to cause uterine contractions, and in Ghana and Nigeria an extract of the root or root bark is taken as an abortifacient. In Côte d'Ivoire, on the other hand, a root decoction with salt obtained from ash of the rachis of oil palm is recorded to be drunk to prevent abortion. In Ethiopia an infusion of the powdered root bark is drunk for the treatment of lymphatic swellings. In Madagascar a root decoction is taken against haemorrhage. A preparation of young leaves with lemon juice is drunk in Côte d'Ivoire against constipation, but in Ghana a cold infusion of the leaf with lime juice is used for the treatment of dysentery. In Ghana the macerated leaf is taken against vomiting, while the fresh leaf is used for the treatment of ulcers, either as a covering (after heating) or as a powder dressing after heating with the fruit of *Piper guineense* Schumach. & Thonn. In Ghana the leaf and crushed seed are applied to sores and made into poultices for the treatment of bruises and swellings. In Cameroon a leaf decoction is drunk for the treatment of typhoid fever. In Nigeria the flower is used for relieving dysentery. In Ghana a paste of ground seeds is applied against headache. In Mauritius the bark and seeds have been used against tumours.

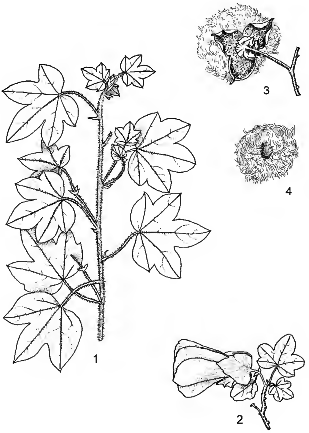
Production and international trade According to FAO estimates the annual world cotton production in 2004–2008 was about 70 million t seed cotton (unginned cotton, containing seed, lint and fuzz), from 34 million ha. However, the largest part (more than 90%) of the world cotton production comes from *Gossypium hirsutum*, which is highly productive and shows strong yield responses to improved growing conditions, fertilizers, crop protection and supplementary irrigation. Most of the remainder comes from *Gossypium barbadense*. *Gossypium arboreum* is grown to some extent in Africa and Asia. In India, for instance, about 10–15% of the cotton area is under *Gossypium arboreum*. In tropical Africa *Gossypium arboreum* is grown for domestic use only.

Properties Cotton fibres are unicellular extensions of epidermis cells of the seed. Two types of fibres are distinguished: long fibres ('lint') and short fibres ('fuzz' or 'linters'). Cotton lint fibres are 10–40(–64) mm long, with a diameter of (12–)18–28(–42) μm and a length:width ratio of 1000–4000. The lint fibres of *Gossypium arboreum* are shorter (normally less than 25 mm long) and coarser than those of *Gossypium hirsutum* and *Gossypium barbadense*, and with thicker cell walls. Fuzz fibres are similar in appearance to lint fibres, but shorter (2–7 mm long), more cylindrical and with thicker walls.

Apart from fibre length and its uniformity, the most important properties of cotton are fineness (diameter), maturity, strength and elasticity. The combined fineness and maturity (the degree to which the secondary cell wall has developed) of cotton fibre is usually determined by resistance to air flow, and expressed in a value called 'micronaire', reflecting the linear density of fibres. Typical values of the tensile strength, elongation at break, and Young's modulus of cotton fibre are 285–595 N/mm^2, 7.0–8.0% and 5500–12,600 N/mm^2, respectively. Among the world's major textile fibres, cotton has a unique combination of properties, being strong, comfortable, washable, durable and printable. It also blends well with other fibres to give it additional strength, lustre and crease resistance. On a dry weight basis, cotton fibre contains 88–96% α-cellulose, 3–6% hemicelluloses and 1–2% lignin.

Cotton seeds remaining after ginning consist of linters (5–10%), oil (15–33%), oilcake (33–45%) and hulls (24–34%). Cottonseed oil is a semi-drying oil obtained by mechanical and/or solvent oil extraction from the seed. The principal fatty acids in cottonseed oil are linoleic acid (42–59%), palmitic acid (20–34%) and oleic acid (13–25%). *Gossypium arboreum* seed oil with oleic acid levels as high as 32% has been reported. Cotton seed oil also contains 0.5–1(–2)% cyclopropenoid fatty acids, which are known to cause physiological disorders in animals. The oil as well as other plant parts of *Gossypium* species contain gossypol, a triterpenoid aldehyde, which is toxic to humans and animals, monogastric animals in particular. Gossypol has insecticidal, antimicrobial, antifertility and antitumour properties. Gossypol and related compounds have been implicated in conferring insect tolerance or resistance and antimicrobial properties to cotton plants. Glandless, gossypol-free cultivars exist, but they are more vulnerable to pests. Gossypol can be removed from the oil by solvent extraction, following mechanical and/or solvent oil extraction from the seed. The cake and meal contain over 40% crude protein, but are not without danger for monogastric animals, because of the gossypol they contain. The gossypol in the cake can be removed or made harmless by chemical (ferrous salts) or physical (heating) means, but this is more difficult to achieve economically than removing gossypol from the oil.

Methanol and dichloromethane leaf extracts of *Gossypium arboreum* showed activity against the Gram-positive bacteria *Bacillus subtilis* and *Staphylococcus aureus*, the Gram-negative bacteria *Escherichia coli* and *Pseudomonas aeruginosa* and the yeast *Candida albicans*. In another study an aqueous extract of the leaves and seeds showed only weak antibacterial activity against *Bacillus subtilis, Escherichia coli, Micrococcus flavus, Pseudomonas aeruginosa* and *Staphylococcus aureus*, but the extract stimulated growth of human dermal fibroblast cells and had an antioxidant protective effect on these cells, which gives some support to the traditional use of *Gossypium arboreum* leaves and seeds for wound healing. A methanol extract of the root of *Gossypium arboreum* showed antibacterial activity against *Bacillus polymixa* and *Escherichia coli*. Petals and flavonoids isolated from the petals showed antibacterial activity against *Pseudomonas maltophilia* and *Enterobacter cloacae*.



Gossypium arboreum – 1, leafy branch; 2, part of branch with flower; 3, dehisced fruit; 4, seed. Redrawn and adapted by H. de Vries

Description Shrub or small tree up to 3 m tall, extremely variable, most parts densely covered with minute stellate hairs and patent simple hairs, nearly all parts irregularly dotted with black oil glands; twigs slender, terete. Leaves spirally arranged; stipules linear to lanceolate, often falcate, 4–15 mm long, caducous; petiole 1–14 cm long; blade ovate to orbicular in outline, 2–12 cm in diameter, palmately lobed or parted with 3–7 segments, frequently with an extra tooth in the sinuses, base cordate, lobes ovate to narrowly lanceolate, apex acute or acuminate, sometimes obtuse, margin entire, pedately 5–9-veined, nectaries usually inconspicious or absent. Flowers solitary, usually on sympodial branches; pedicel 0.5–6 cm long not articulated, usually without apical nectaries; epicalyx segments (bracteoles) 3, closely embracing the corolla and fruit, rarely spreading, united for 1 cm or more, 1.5–3.5 cm × 1.5–3 cm, slightly accrescent in fruit, base deeply cordate, apex acute, margin entire or remotely toothed, glabrous inside, hairy outside, persistent; calyx cupular, 5–12 mm long, truncate to inconspicuously 5-dentate, glabrous; corolla at opening usually cream to yellow and after 1–2 days turning red or purple, with or without a purplish centre, petals 5, imbricate, obovate, 2.5–4.5 cm long; stamens numerous, forming a column 1.5–2 cm long, filaments 1.5–4 mm long, anthers 1-celled; pistil with 3–5-celled ovary and one short style with clavate, 3–5-sulcate stigma. Fruit ('boll') an globose, ovoid or elongate capsule 1.5–2.5 cm in diameter, beak 3–5 mm long, opening loculicidally, after dehiscing and splitting often reflexed, outside densely pitted and glabrous, 3(–4)-celled with 5–8 seeds per cell. Seeds ovoid to globular, 5–8 mm in diameter, with a copious covering of fairly long, white or rusty, woolly hairs (lint or floss) firmly attached to the seed, and also with a fine, short tomentum (fuzz). Seedling with epigeal germination.

Other botanical information *Gossypium* comprises about 50 species distributed in warm temperate to tropical zones. The origin of the genus is unknown, but 3 primary centres of diversity exist: in Australia, in north-eastern Africa to Arabia, and in western-central to southern Mexico. The 4 cultivated cottons of the world (the Old World diploids *Gossypium arboreum* and *Gossypium herbaceum* and the New World tetraploids *Gossypium barbadense* and *Gossypium hirsutum*) have been domesticated independently in different parts of the world. The taxonomy of *Gossypium* is complicated, partly due to the domestication of 4 distinct species and extensive interspecific hybridization. The literature is confusing and authors disagree on the identity of many species, subspecies, sections, varieties, forms, races and cultivars that have been distinguished. Currently the taxonomic system of P.A. Fryxell, with about 50 species grouped into 4 subgenera and 8 sections, is the most generally accepted one. It is mainly based on morphological and geographical data, but is confirmed by cytogenetic and molecular evidence. Cytological research has led to the recognition of 8 basic diploid 'genomic groups', designated A through G, plus K. In general, species within a genomic group can form fertile interspecific hybrids. *Gossypium arboreum* and *Gossypium herbaceum* are included in subgenus *Gossypium*: diploid Old World species with A-genome, whereas *Gossypium barbadense* and *Gossypium hirsutum* belong to subgenus *Karpas*: tetraploid New World species with AD-genome.

The large variation within *Gossypium arboreum* has been classified into 6 geographical groups, usually indicated as races:

- bengalense: annual cottons, cultivated in India and Bangladesh in regions that are subject to frost; the lint is coarse and short.
- burmanicum: perennial cottons, cultivated in north-eastern India and South-East Asia, particularly Myanmar; the lint is variable.
- cernuum: annual, long-bolled cottons, grown in northern India (Assam); included by some in race burmanicum.
- indicum: mostly perennial shrubs, although in India some annual cultivars ('Rozi' cottons) exist; the most primitive cultivated group within *Gossypium arboreum*, mostly grown in Gujarat (India), along the eastern coast of Africa and in Madagascar; the lint is scanty, coarse and often coloured.
- sinense: annual, early maturing cottons, cultivated commercially in China, Korea and Japan; it provides the original Asian cotton.
- soudanense: the 'Senaar' tree cottons, large perennial shrubs or small trees; probably reached north-eastern Africa from India about 2000 years ago, grown in the northern part of tropical Africa; the lint varies from coarse to moderately fine.

Anatomy Cotton lint fibres are smooth-looking, ribbon-like and twisted, with the fibre walls showing longitudinal and spiral striations. The fibre walls contain many layers of cellulose chains, which run spirally and give dry fibres their characteristic twisting appearance. The hairs are covered with a waxy cuticle, giving unprocessed fibre a greasy feel and making it water-repellent.

Growth and development The shoot system of cotton is dimorphic, with the main axis and lower branches (emerging from axillary buds) being monopodial and vegetative, whereas the fruiting branches (emerging from extra-axillary buds) are sympodial. Fruiting branches develop as primary branches higher on the main stem and as secondary branches on vegetative branches. Generally only one fruiting branch develops at each node, with 3–5 fruits per branch. The first fruiting branch appears at node 4–5 of the main stem, between 1 and 2 months after sowing, and visible flower buds appear as small, green, pyramidal structures, known as 'squares'. They need 20–35 days to develop into open flowers. The flowers mostly open near dawn and pollination normally occurs within a few hours. Self-pollination is the predominant mating system, but visiting insects can cause considerable outcrossing (up to 40%). Flowering peaks at 3(–6) weeks after the onset and may continue for about 6 weeks. The fruits grow very quickly after pollination, reaching their final size at about 20–25 days. After a further (20–)25–45(–60) days, depending on genotype and environmental conditions, they are ripe. Usually the dry fruits open at their sutures and the white, fluffy fibre-mass emerges. The seeds remain attached to the placenta and are only separated by picking or by very strong rain or wind.

During the first 2–4 weeks after flowering (the elongation phase) the fibres grow rapidly, reaching their full length, and during the next 4–6 weeks (the secondary thickening phase) the cell walls of the fibres thicken through deposition of cellulose in consecutive layers. The cell wall thickness of a fibre, or the degree to which the fibre has been filled with cellulose, mainly depends on plant vigour during ripening. Upon boll opening the fibre dries and the lumen collapses, resulting in the characteristic twisted, ribbon-like appearance of the fibre that makes it spinnable.

Shedding of squares and young bolls is common in cotton. It is aggravated by adverse conditions such as prolonged overcast weather, extreme temperatures, water stress, waterlogging, nutrient deficiencies, diseases and insect damage. Commonly 60% of the squares and young bolls are shed, but flowers are rarely shed. The ability to overcome adverse events by compensatory growth is characteristic for cotton. However, recovery is only partial and insignificant when severe insect damage occurs late in the season.

Ecology *Gossypium arboreum* requires a temperature of (18–)26–36(–38)°C and a rainfall of (500–)750–1250(–1500) mm during the growing season. It can be grown on deep, light to heavy, well-drained soils with a moderate fertility and a pH of (5.3–)6–7.2(–8.5). In East Africa it occurs from sea-level up to 1000 m altitude.

Propagation and planting Cotton is propagated by seed. The 1000-seed weight of *Gossypium arboreum* is 46–91 g. It is possible to propagate cotton vegetatively by cuttings, budding or grafting. The development of rapid, reproducible and genotype-independent systems of in-vitro propagation of *Gossypium* species been difficult, though methods have now been developed to produce large numbers of somatic embryos from callus from hypocotyl or cotyledon explants of *Gossypium arboreum, Gossypium barbadense, Gossypium herbaceum* and *Gossypium hirsutum*.

Management In tropical Africa, for instance in Niger and Cameroon, *Gossypium arboreum* is usually not grown as a field crop, but as isolated plants near homesteads. Growing *Gossypium arboreum* and other cotton species as perennials was formerly very common, but it has been discouraged, because perennial cotton can act as a host reservoir for cotton pests and diseases. Locally, for instance in Cameroon, fields with perennial cotton plants can still been seen. *Gossypium arboreum* plants 15–20 years old have been observed, with stems up to 15 cm in diameter; they are usually pollarded.

Diseases and pests Diseases are less important in cotton than pests. The most widespread diseases are bacterial blight, leaf spot, blackarm or boll rot caused by *Xanthomonas axonopodis* pv. *malvacearum* (synonym: *Xanthomonas campestris* pv. *malvacearum*), anthracnose caused by *Glomerella gossypii* (anamorph: *Colletotrichum gossypii*), Fusarium wilt caused by *Fusarium oxysporum*, and Verticillium wilt caused by *Verticillium dahliae*. Before resistance was found and incorporated in *Gossypium hirsutum* cultivars, bacterial blight caused seed cotton yield losses up to 28% in African cotton crops, and it is considered partially responsible for the sustained cultivation of *Gossypium arboreum* and *Gossypium herbaceum* in Africa and Asia. Bacterial blight is controlled by growing cotton only once every 3 or more years on the same field, removing the harvest remains and seed treatment. Anthracnose can be controlled by the same measures, but resistant cultivars are not available. *Gossypium arboreum* cultivars with resistance to Fusarium wilt are available. Cropping methods to control wilt diseases include crop rotation, sufficient K-fertilization and the control of nematodes. The most important virus diseases of cotton in tropical Africa are leaf curl, African cotton mosaic and cotton blue disease. Virus diseases are controlled by eliminating reservoir hosts and vectors, and by using tolerant or resistant cultivars.

Cotton suffers from a wide spectrum of pests. Bollworms are among the most serious pests. They feed inside the bolls, damaging lint and seed and so causing considerable reduction in yield and quality. The main bollworms are American bollworm (*Helicoverpa armigera*), pink bollworm (*Pectinophora gossypiella*) and spiny bollworm (*Earias* spp.). Spiny bollworm, to which *Gossypium arboreum* and *Gossypium barbadense* seem less susceptible than *Gossypium hirsutum*, has a serious early effect of tipboring in the main stem leading to excessive formation of vegetative branches and delaying the setting of bolls, which makes them vulnerable to mid-season American bollworm and stainers. Resistance to bollworms has not been achieved to the desired extent, and their control has long relied heavily on insecticides.

Leaf, stem and bud-sucking bugs can cause considerable damage. Jassids (*Amrasca*, *Empoasca*, *Erythroneura*, *Jacobiella* and *Jacobisca* spp.) are the first pests to appear, but a dense coating of long hairs on leaves and stems provides good protection. Whitefly (*Bemisia tabaci*) and cotton aphid (*Aphis gossypii*) are pests later in the season; the former is the vector of leaf curl and African cotton mosaic, the latter of cotton blue disease. Early sowing, weeding and harvesting and the use of short-season cultivars can reduce their damage. Cotton stainers (*Dysdercus* spp.) occur in all cotton-growing countries. They pierce the green bolls and inject the fungus *Nematospora gossypii*, which causes yellow staining of the lint, resulting in lower quality. About 4 alternating sprays of organophosphates and pyrethroids can overcome this pest. Fairly effective preventive control can be obtained by strict phytosanitation, early cropping of maize or sorghum followed by early ploughing and close planting of cotton using an early-maturing cultivar. Close relatives of cotton, such as *Abutilon* species growing nearby are alternative hosts of cotton pests, especially stainers.

Insect pests in cotton have been effectively controlled since 1945 with the use of insecticides. The repeated development of resistance of insect pests (especially the American bollworm) to new insecticides has in some countries led to excessive spraying, up to 15 sprays per season, killing all natural enemies. This may also induce outbreaks of previously minor pests, requiring additional spraying. To reduce the use of pesticides, the application of Integrated Pest Management (IPM) or Integrated Weed and Pest Management (IWPM) is advocated. Very early field preparation including repeated weeding, fertilizer application, early planting of jassid-resistant cultivars, gapping, thinning and judicious use of pesticides on the basis of insect monitoring and damage thresholds, form the basis of interacting IWPM farming practices. Preventive weed control by ploughing or hoeing promptly after clearing the preceding crop stores moisture from unexpected storms in the subsoil which makes it possible to plant early. This encourages early fruiting well ahead of the main pest, American bollworm, and provides ample time for compensatory fruiting in case of early fruit damage. As insecticides against jassids are no longer needed they do not kill the natural enemies which control American bollworm in its vulnerable young stage. By the time the later pink bollworms, stainers and whitefly occur, the main crop will be safe.

The most widely distributed economically important nematode in cotton is the root-knot nematode (*Meloidogyne* spp.), whereas the reniform nematode (*Rotylenchus* spp.) is more restricted to tropical and subtropical environments. *Gossypium arboreum*, *Gossypium herbaceum* and *Gossypium barbadense* are less susceptible to the reniform nematode than *Gossypium hirsutum*. Nematodes can be controlled by rotation and chemicals, whereas cotton genotypes have been developed with some tolerance to the reniform nematode.

Harvesting In tropical Africa cotton harvesting is generally done by hand. After the cotton has been harvested, the cotton stems should be uprooted and burnt to prevent the build-up of pest and diseases.

Yield A seed cotton yield of up to 4 t/ha is possible under optimal conditions, but in practice it is seldom over 2.5 t/ha and the average world yield is about 2 t/ha. In most tropical African countries the yield is around 1 t/ha. Seed cotton of primitive cultivars yields 20–25% fibre after ginning, whereas good cultivars of upland cotton have a 'ginning-outturn' of at least 35% and sometimes over 40%. Some modern *Gossypium arboreum* and *Gossypium herbaceum* cultivars grown in India and China also yield up to 40% lint.

Handling after harvest Cotton lint is removed from the seeds by ginning, which can be done with a hand gin (capacity of 2–3 kg lint/hour) or mechanically. Mechanical ginning can be done with a saw gin (capacity of 300 kg lint/hour) for the shorter stapled cottons, or with the more gentle roller gin (capacity of 30 kg lint/hour) for the longer stapled fine types. In some African countries, such as Kenya and Uganda, roller ginning is common, even for shorter stapled cotton. In West and Central Africa manual ginning may be done by placing the seed cotton on a block of wood or a flat stone, and squeezing out the seeds by rolling an iron or wooden rod over it. The optimum moisture content of the fibre for ginning is 5–7%. When the moisture content is lower, excessive fibre damage occurs; when it is higher, the amount of broken seeds is higher.

Genetic resources In India about 1900

Gossypium arboreum accessions are kept at the Central Institute for Cotton Research (CICR) in Nagpur and Coimbatore, and the National Bureau for Plant Genetic Resources (NBPGR) in New Delhi. The National Collection of Gossypium Germplasm housed at the Southern Plains Agricultural Research Center (SPARC), College Station, Texas, United States, has 1700 *Gossypium arboreum* accessions. In Uzbekistan the Cotton Breeding Institute, the Institute of Genetics and Plant Experimental Biology and the National University of Uzbekistan together hold about 1200 *Gossypium arboreum* accessions. The Chinese Academy of Agriculture Sciences (CAAS) in Nanjing, China, and the N.I.Vavilov Institute of Plant Industry (VIR) in St Petersburg, Russia, each hold about 400 accessions of *Gossypium arboreum*, and the genebank of the Centre de Coopération Internationale en Recherche Agronomique pour le Développement (CIRAD) at Montpellier, France, about 70.

Breeding Until the 1930s cotton breeding was limited to crossing within the diploid and tetraploid groups. After this, polyploidization of the diploids greatly increased breeding opportunities. Crosses between Old World and New World genotypes have become important, especially for resistance breeding and the breeding of better cultivars for regions in Asia where *Gossypium arboreum* and *Gossypium herbaceum* grow well, but *Gossypium hirsutum* does not. F1 hybrid cultivars with considerable hybrid vigour for yield have been successfully developed. However, the available systems of cytoplasmic male sterility have been inadequate for large-scale production of hybrid seed, mainly due to incomplete expression of fertility restorer genes in the male parents. Current use of cotton hybrids is limited to South Asia and China, where seed production by manual emasculation and pollination is economically feasible because of low labour costs.

The main objectives in cotton breeding, apart from higher yields, are photoperiod-insensitivity, early maturity, adaptation to mechanical harvesting (through low growth, little branching, short flowering period, loosely attached seeds, less hairy leaves), fibre quality (length, fineness, strength and elasticity), seed quality (high oil content and low gossypol content, increased suitability of the presscake as a source of protein for humans and animals), resistance to diseases (e.g. bacterial blight and Fusarium wilt) and pests (e.g. bollworms, jassids) and tolerance to drought, cold and salinity. There has been little progress in breeding for pest resistance (except for resistance to jassids), but much success has been obtained in resistance and tolerance to Fusarium and Verticillium wilts, bacterial blight and nematodes.

Prospects Cotton will remain very important on a worldwide scale, because of its excellent fibre properties and low price, but *Gossypium hirsutum* and *Gossypium barbadense* will remain the most important species, and the role of *Gossypium arboreum* will remain marginal. In tropical Africa *Gossypium arboreum* will probably remain to be grown for domestic use, mainly for medicinal purposes.

Major references Burkill, 1997; Fryxell, 1978; Hutchinson, 1962; Kerkhoven & Mutsaers, 2003; Kulkarni et al., 2009; Neuwinger, 2000; Peeters et al., 2001; Seignobos & Schwendiman, 1991; Smith & Cothren (Editors), 1999; Verdcourt & Mwachala, 2009.

Other references Adjanohoun & Aké Assi, 1979; Ajayi, 2008; Annan & Houghton, 2008; Bernholt et al., 2009; Boiteau, Boiteau & Allorge-Boiteau, 1999; Campbell et al., 2010; ECOCROP, 2007a; Ekundayo & Ezeogu, 2006; Fisseha Mesfin, Sebsebe Demissew & Tilahun Teklehaymanot, 2009; Hochreutiner, 1955; Irvine, 1961; Jarman, 1998; Jiofack et al., 2008; Keay, 1958d; Kirkpatrick & Rothrock, 2001; Lopes & Steidle Neto, 2011; Matthews & Tunstall (Editors), 1994; Pandey & Suri, 1982; Roecklein & Leung (Editors), 1987; Waage & Hedin, 1984.

Sources of illustration Hochreutiner, 1955.

Authors M. Brink

Based on PROSEA 17: Fibre plants.

GOSSYPIUM BARBADENSE L.

Protologue Sp. pl. 2: 693 (1753).

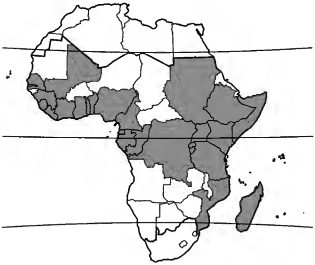
Family Malvaceae

Chromosome number $2n = 52$

Synonyms *Gossypium vitifolium* Lam. (1786), *Gossypium peruvianum* Cav. (1788), *Gossypium acuminatum* Roxb. ex G.Don (1831), *Gossypium brasiliense* Macfad. (1837).

Vernacular names Cotton, sea island cotton, Egyptian cotton, pima cotton (En). Coton, cotonnier, cotonnier d'Egypte, coton des Indes occidentales (Fr). Algodoeiro, algodoeiro americano (Po). Pamba (Sw).

Origin and geographic distribution *Gossypium barbadense* probably originated in Peru as a cross between *Gossypium herbaceum* L. and *Gossypium raimondii* Ulbrich or *Gossypium gossypioides* (Ulbrich) Standley. It grows



Gossypium barbadense – planted and naturalized

naturally on the coasts of Peru and Ecuador. It was domesticated in north-western South America. In Peru cotton products from *Gossypium barbadense* such as yarn, cordage and fishing nets date back to about 2500 BC. Cultivation spread over South and Central America and *Gossypium barbadense* has been introduced after 1492 into Africa, Asia and the Pacific Islands. It was introduced into the United States in 1785 where it was known as 'sea island cotton', as opposed to 'upland cotton' (*Gossypium hirsutum* L.). It is now widely cultivated in the warmer parts of the world and sometimes naturalized. It is the main cotton in Egypt and the West Indies, while other major producers include Sudan, Peru and the United States. In some parts of tropical Africa, e.g. in Côte d'Ivoire, it has to a large extent been replaced by the more productive *Gossypium hirsutum*.

In this article the word 'cotton' refers to information referring to all 4 cultivated *Gossypium* species (*Gossypium arboreum* L., *Gossypium barbadense*, *Gossypium herbaceum* and *Gossypium hirsutum*); where information refers to *Gossypium barbadense* only, this is stated explicitly.

Uses Cotton is the most important group of fibre plants in the world. The main fibres of cotton plants are the longer seed hairs ('lint'), used for making yarn to be woven into textile fabrics, alone or in combination with other plant, animal or synthetic fibres. Cotton lint is also made into other products including sewing thread, cordage and fishing nets. The lint of *Gossypium barbadense* is especially valued for use in high-quality textiles, luxury fabrics, yarns and sewing thread. Cotton textile cuttings and rags serve in the paper industry for the production of the best writing, book and drawing paper. Short fibres ('fuzz' or 'linters') are processed into a range of products, including papers, twine, automobile upholstery, explosives, plastics and photographic film. Linter pulp is made into various types of paper, depending on its grade. Linters have also been used for the production of cellulose acetate and viscose. Cotton stalks are processed into paper and paperboard, for instance in China, and into cement-bonded particle board.

Cotton is an important oil plant. Oil obtained from cotton seed is industrially used in a range of products, including margarine, mayonnaise, salad and cooking oils, salad dressing and shortening. It is also made into soap, cosmetics, lubricants, sulphonated oils and protective coatings. Locally it serves for cooking and frying. Blends of cotton-oil biodiesel and diesel fuel can be used in conventional diesel engines without any major changes. The seed cake remaining after oil extraction is an important protein concentrate for livestock. Low-grade cake is used as manure. The whole seed can be fed to ruminants, which are less sensitive to the toxic gossypol in the seed than non-ruminants, or is applied as manure. Hulls are a low-grade roughage for livestock or serve as bedding or fuel. Leftover bolls, leaves and thin twigs are grazed by ruminants. Dry stalks serve as household fuel.

In West Africa the fibre of *Gossypium barbadense* is locally used for weaving articles such as waistbands, neckerchiefs and armlets. In southern Nigeria it forms the basis of a local spinning and weaving industry of some importance. In Cameroon the fibre is made into cloth used for dowries and in burials. In Gabon the fibre is made into bags. In DR Congo it is used for making coarse textiles, cords, string, fishing nets and straps. *Gossypium barbadense* is sometimes grown as an ornamental. It is a bee forage, giving higher honey yields than *Gossypium hirsutum*.

Gossypium barbadense is widely used in African traditional medicine. In Senegal a leaf infusion is used as an eyewash for the treatment of eye affections. In Côte d'Ivoire dampened fibre is used as a wound dressing, and fibre soaked in oil is used for drawing. In Mali the leaf juice diluted with water is used as eye drops for the treatment of conjunctivitis. In Benin the leaf juice is taken for the treatment of cough, dystocia and vertigo, and a decoction of the leaves with those of *Pergularia daemia* (Forssk.) Chiov. is taken against convulsions. In Cameroon a leaf decoction is taken for the treatment of jaundice, pounded leaves are used in poultices against stomach-ache and constipation, and seed oil is used against otitis. In Gabon a leaf maceration is taken against gonorrhoea and as an emetic, while the sap is considered emollient and externally applied against itch. In Congo the leaf sap is instilled in the ear for the treatment of otitis, leaf decoctions are drunk against cough, and the leaf is rubbed on the body to cure scabies. In DR Congo a leaf infusion is drunk for the treatment of colds, bronchitis, rheumatism and haemorrhoids, and kept in the mouth to treat dental caries and gingivitis. Pounded leaves are applied on cuts, abscesses and used for the treatment of leprosy. Pulped young shoots are used against palpitations, and the fibre in dressings on wounds. In Kenya the lint is used as dressing on sores.

Production and international trade According to FAO estimates the annual world cotton production in 2004–2008 was about 70 million t seed cotton (unginned cotton, containing seed, lint and fuzz), but the largest part (more than 90%) of the world cotton production comes from *Gossypium hirsutum*. Most of the remainder comes from *Gossypium barbadense*, which produces longer, stronger, finer and more expensive fibre than *Gossypium hirsutum* but yields less and shows limited adaptation to most cotton-growing areas. In 2004 the main producers of *Gossypium barbadense* were the United States, China, India and Egypt. In West Africa commercial production of *Gossypium barbadense* fibre takes place in Togo and Nigeria. Two other cotton species, *Gossypium arboreum* and *Gossypium herbaceum*, are grown to some extent in Africa and Asia.

Properties Cotton fibres are unicellular extensions of epidermis cells of the seed. Two types of fibres are distinguished: long fibres ('lint') and short fibres ('fuzz' or 'linters'). Cotton lint fibres are 10–40(–64) mm long, with a diameter of (12–)18–28(–42) μm and a length:width ratio of 1000–4000. *Gossypium barbadense* yields the highest quality lint of all cottons, being white, silky and 30–40(–64) mm long. In international trade, the fibre length or 'staple length' of cotton is expressed in fractions of inches. Fuzz fibres are similar in appearance to lint fibres, but shorter (2–7 mm long), more cylindrical and with thicker walls. Seeds of some modern *Gossypium barbadense* cultivars do not produce any fuzz.

Apart from fibre length and its uniformity, the most important properties of cotton are fineness (diameter), maturity, strength and elasticity. The combined fineness and maturity (the degree to which the secondary cell wall has developed) of cotton fibre is usually determined by resistance to air flow, and expressed in a value called 'micronaire', reflecting the linear density of fibres. Typical values of the tensile strength, elongation at break, and Young's modulus of cotton fibre are 285–595 N/mm^2, 7.0–8.0% and 5500–12,600 N/mm^2, respectively. Among the world's major textile fibres, cotton has a unique combination of properties, being strong, comfortable, washable, durable and printable. It also blends well with other fibres to give it additional strength, lustre and crease resistance. On a dry weight basis, cotton fibre contains 88–96% α-cellulose, 3–6% hemicelluloses and 1–2% lignin.

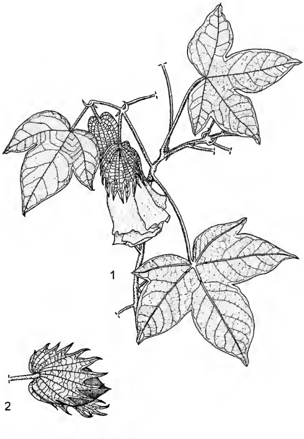
Cotton seeds remaining after ginning consist of linters (5–10%), oil (15–33%), oilcake (33–45%) and hulls (24–34%). Cottonseed oil is a semi-drying oil obtained by mechanical and/or solvent oil extraction from the seed. The principal fatty acids in cottonseed oil are linoleic acid (42–59%), palmitic acid (20–34%) and oleic acid (13–25%). The seed oil also contains 0.5–1(–2)% cyclopropenoid fatty acids, which are known to cause physiological disorders in animals. The oil as well as other plant parts of *Gossypium* species contain gossypol, a triterpenoid aldehyde, which is toxic to humans and animals, monogastric animals in particular. Gossypol has insecticidal, antimicrobial, antifertility and antitumour properties. Gossypol and related compounds have been implicated in conferring insect tolerance or resistance and antimicrobial properties to cotton plants. Glandless, gossypol-free cultivars exist, but they are more vulnerable to pests. The gossypol content of *Gossypium barbadense* seeds (0.60–1.15% of total dry matter) is generally higher than that of *Gossypium hirsutum* (0.51–0.77%), with a higher proportion of the gossypol present in the more biologically active free form. Gossypol can be removed from the oil by solvent extraction, following mechanical and/or solvent oil extraction from the seed. The cake and meal contain over 40% crude protein, but are not without danger for monogastric animals, because of the gossypol they contain. The gossypol in the cake can be removed or made harmless by chemical (ferrous salts) or physical (heating) means, but this is more difficult to achieve economically than removing gossypol from the oil.

When whole seeds are fed to cows, the fuzz on the seeds slows down the passage of the seed through the digestive tract, and fuzz-free *Gossypium barbadense* seeds are not as completely digested as fuzzy seeds. To increase their digestibility they are cracked or processed. It has been suggested that adult cattle should have less than 0.1–0.2% gossypol in the total ration, which would amount to 2.7–3.6 kg of unprocessed *Gossypium barbadense* seed per day.

A crude leaf extract of *Gossypium barbadense* and its methanol fraction showed in-vivo hypotensive effect in rats.

Adulterations and substitutes The fibre of *Gossypium barbadense* can be substituted by that of *Gossypium hirsutum* and the less important *Gossypium arboreum* and *Gossypium herbaceum*, but fibre of the latter three species is shorter and of lower quality than that of *Gossypium barbadense*.

Description Perennial shrub or annual subshrub up to 3 m tall, with nearly all parts irregularly dotted with black oil glands; twigs first angled, later terete, often tinged with purple. Leaves spirally arranged; stipules linear, lanceolate or ovate, in flowering shoots often broadly ovate to orbicular and auricled at base, 1–5 cm long; petiole ½–⅔ the length of the blade; blade orbicular to broadly ovate in outline, 8–20 cm in diameter, 3–7-palmately lobed with central segment largest, upper leaves sometimes not segmented, lobes ovate to lanceolate, base cordate, margin entire, pedately 3–9-veined, with 1–3 central veins with an elliptical nectary slightly above the base beneath. Flowers solitary, usually on sympodial branches; pedicel shorter than petiole, not articulated, sharply trigonous, usually bearing nectaries below the insertion of the epicalyx segments; epicalyx segments (bracteoles) 3, erect, appressed against corolla or fruit, orbicular to ovate, 4–6 cm long, at base cordate and strongly auricled, with 5–17 acuminate teeth, persistent; calyx cupular, 8–10 mm long, with 5 obtuse short teeth at truncate apex, densely gland-dotted, bearing 3 nectaries outside at the base, splitting after flowering; corolla usually yellow with a dark red or purple spot at the base, petals 5, imbricate, obovate, 5–8 cm long, truncate and emarginate at apex; stamens numerous, forming an erect column 2.5–4 cm long, filaments short, anthers 1-celled; pistil with 3–5-celled ovary and one short style with clavate, 3–5-sulcate stigma. Fruit ('boll') an ovoid to fusiform capsule 3.5–6 cm long, beaked, glabrous, densely pitted, black, opening loculicidally, 3-celled with several seeds per cell. Seeds ovoid, 8–10 mm long, with an acute hilum, black to dark brown, with a dense covering of long, fine, white woolly hairs (lint or floss) and a fine, short tomentum (fuzz) everywhere or only at the hilum or absent. Seedling with epigeal germination.



Gossypium barbadense – 1, flowering branch; 2, fruit.
Redrawn and adapted by H. de Vries

Other botanical information *Gossypium* comprises about 50 species distributed in warm temperate to tropical zones. The origin of the genus is unknown, but 3 primary centres of diversity exist: in Australia, in north-eastern Africa to Arabia, and in western-central to southern Mexico. The 4 cultivated cottons of the world (the Old World diploids *Gossypium arboreum* and *Gossypium herbaceum* and the New World tetraploids *Gossypium barbadense* and *Gossypium hirsutum*) have been domesticated independently in different parts of the world. The taxonomy of *Gossypium* is complicated, partly due to the domestication of 4 distinct species and extensive interspecific hybridization. The literature is confusing and authors disagree on the identity of many species, subspecies, sections, varieties, forms, races and cultivars that have been distinguished. Currently the taxonomic system of P.A. Fryxell, with about 50 species grouped into 4 subgenera and 8 sections, is the most generally accepted one. It is mainly based on morphological and geographical data, but is confirmed by cytogenetic and molecular evidence. Cytological research has led to the recognition of 8 basic diploid 'genomic groups', designated A through G, plus K. In general, species within a genomic group can form fertile interspecific hybrids. *Gossypium barbadense* and *Gossypium hirsutum* belong to subgenus *Karpas*: tetraploid New World species with AD-genome, whereas *Gossypium arboreum* and *Gossypium herbaceum* are included in subgenus *Gossypium*: diploid Old World species with A-genome.

Within *Gossypium barbadense* 2 varieties are distinguished:

- var. *barbadense*: annual shrub, cultivated mainly in the West Indies, Central America and the southern parts of the United States, but also in Egypt and Sudan.
- var. *braziliense* (Raf.) Fryxell: the 'kidney cottons' of the Amazon Basin, with the seeds in each cell of the fruit fused into a solid kidney-shaped mass; the kidney seed mass facilitates hand ginning; it is perhaps better considered a geographically restricted domesticated form of *Gossypium barbadense* than a taxonomic entity.

Formerly, a third variety was distinguished, var. *darwinii* (Watt) J.B.Hutchinson, but it has been reclassified as a separate species, *Gossypium darwinii* Watt: a perennial shrub with fine brown lint, endemic to the Galapagos Islands. This separation is supported by evidence from molecular data.

Anatomy Cotton lint fibres are smooth-looking, ribbon-like and twisted, with the fibre walls showing longitudinal and spiral striations. The fibre walls contain many layers of cellulose chains, which run spirally and give dry fibres their characteristic twisting appearance. The hairs are covered with a waxy cuticle, giving unprocessed fibre a greasy feel and making it water-repellent. On drying at maturity the fibres lose their tubular shape and become ribbon-like (kidney-shaped in cross-section), twisting in different directions forming the well-known convolutions. Desiccation at maturity is an irreversible physical process, generating technological properties that make the cotton fibre very suitable for textile production.

Growth and development Cotton is normally a perennial plant with an indeterminate growth habit, but is usually grown as an annual, with the formation of nodes on the main stem stopped by fruit load, temperature, soil moisture, photoperiod, or a combination of these factors. The crop cycle is 120–220 days. Seedlings emerge 5–15(–30) days after sowing and the first true leaf unfolds 7–9 days later, but these processes vary with temperature. Upon germination, seedlings initiate a long taproot, which can reach a depth of more than 25 cm by the time the cotyledons unfold and may reach a depth of 3 m by mid-season. The plant remains unbranched for about 1 month. The shoot system is dimorphic, with the main axis and lower branches (emerging from axillary buds) being monopodial and vegetative, whereas the fruiting branches (emerging from extra-axillary buds) are sympodial. Fruiting branches develop as primary branches higher on the main stem and as secondary branches on vegetative branches. Generally only one fruiting branch develops at each node, with 3–5 fruits per branch. In *Gossypium barbadense* the first fruiting branch appears at node 10–12 of the main stem, and 50–65 days after emergence the first visible flower buds appear as small, green, pyramidal structures, known as 'squares'. Cotton flowers mostly open near dawn and pollination normally occurs within a few hours. Self-pollination is the predominant mating system, but visiting insects can cause considerable outcrossing (up to 40%). The flowers turn pink in the afternoon and red by the following day. They start withering late on the second day and die on the third day. Flowering peaks at 3(–6) weeks after the onset and may continue for about 6 weeks. The fruits grow very quickly after pollination, reaching their final size in 15–25 days. After a further (20–)25–45(–60) days, depending on genotype and environmental conditions, they are ripe. Usually the dry fruits open at their sutures and the white, fluffy fibre-mass emerges. The seeds remain attached to the placenta and are only separated by picking or by very strong rain or wind.

During the first 2–4 weeks after flowering (the elongation phase) the fibres grow rapidly, reaching their full length, and during the next 4–6 weeks (the secondary thickening phase) the cell walls of the fibres thicken through deposition of cellulose in consecutive layers. The cell wall thickness of a fibre, or the degree to which the fibre has been filled with cellulose, mainly depends on plant vigour during ripening. Upon boll opening the fibre dries and the lumen collapses, resulting in the characteristic twisted, ribbon-like appearance of the fibre that makes it spinnable.

Shedding of squares and young bolls is common in cotton. It is aggravated by adverse conditions such as prolonged overcast weather, extreme temperatures, water stress, waterlogging, nutrient deficiencies, diseases and insect damage. Commonly 60% of the squares and young bolls are shed, but flowers are rarely shed. The ability to overcome adverse events by compensatory growth is characteristic for cotton. However, recovery is only partial and insignificant when severe insect damage occurs late in the season.

Ecology *Gossypium barbadense* requires a temperature of (15–)22–32(–38)°C and a rainfall of (500–)750–1250(–1500) mm during the growing season. It is able to germinate at lower temperatures than *Gossypium hirsutum*. A dry period is needed for fruit ripening. *Gossypium barbadense* is sensitive to frost and does not tolerate shading. It can be grown on medium to deep, light to heavy, well-drained soils with a moderate fertility and a pH of (5.0–)5.2–7.2(–8.5). In Central Africa *Gossypium barbadense* is naturalised in savanna, abandoned villages, around houses and along rivers; in Rwanda and Burundi it occurs up to 1650 m altitude. In East Africa it occurs from sea-level up to 1200 m altitude in gardens and experimental plots and as an escape.

Propagation and planting Cotton is propagated by seed. Seed saved from the previous harvest is rarely used, as the entire harvest is usually sold for ginning. Organized seed multiplication and distribution is important to guarantee seed quality and purity. It is usually recommended that seed be delinted by mechanical or chemical means, with the former being preferred for economic and environmental reasons. For mechanical sowing, removal of the fuzz is essential. Seeds lose their viability rapidly if their moisture content exceeds 10%, but seeds with a moisture content of 7% can be stored in sealed jars for up to 15 years. The 1000-seed weight of *Gossypium barbadense* is 50–100 g.

Cotton is sown directly in the field, and in tropical Africa this is generally done by hand. The sowing date is chosen in such a way that the harvest will coincide with the beginning of the dry season. The planting density varies widely with cultivar, climate and soil characteristics, and cultivation as well as harvest methods. Spacings are 50–120 cm between rows and 15–60 cm within the row. It is advised not to sow less than 5 seeds per hill. About 20–25 kg/ha delinted seed is necessary for sowing, for instance at 80 cm × 30 cm spacing (41,700 hills/ha) with 5 seeds per hill. The seed should not be sown deeper than 4–5 cm in sandy soils and 2–3 cm in clay soils. Fuzzy seeds require more water for germination compared to delinted seeds because imbibition of water is faster in delinted seeds.

Good soil preparation before sowing is very important, because the seedlings do not penetrate hard or crusted soils easily and do not compete well with weeds until they are 3 weeks old. Dry season weeds can be killed by harrowing or hoeing. This greatly reduces weed competition after planting. Early soil cultivation, allowing early planting, extends the growing season. Although hand hoeing is predominant in some parts of Africa, animal- and tractor-drawn ploughs are being used more and more. Most cotton in Africa is grown on the flat, but ridges are necessary on poorly drained soils.

It is possible to propagate cotton vegetatively by cuttings, budding or grafting. In experiments with *Gossypium barbadense* it was found that the rooting ability of cuttings decreased with increasing age of the parent plant from 6 (100% rooting) to 18 weeks (10% rooting). Good results were obtained with cuttings with several internodes, taken from the monopodial, vegetative branches and from the upper half of the main shoot (with the apex removed), but cuttings from generative branches did not form roots. The development of rapid, reproducible and genotype-independent systems of in-vitro propagation of *Gossypium* species has been difficult, though methods have now been developed to produce large numbers of somatic embryos from callus from hypocotyl or cotyledon explants of *Gossypium arboreum*, *Gossypium barbadense*, *Gossypium herbaceum* and *Gossypium hirsutum*.

Cotton is usually grown in rotation with other crops to control pests and soil-borne diseases. It may be intercropped with other annual crops, such as maize, sorghum and grain legumes. In southern Nigeria *Gossypium barbadense* is often grown in mixed cropping systems with yams, maize and cowpea. In Cameroon it can be found along paths and in medicinal gardens.

Management Within 2 weeks after sowing, gaps in the stand of cotton are resown, the crop is thinned and a first weeding round takes place. A second weeding and the final thinning and ridging are carried out 4–5 weeks after sowing, and the final weeding another 2–3 weeks later. In tropical Africa weeding is usually done by hand, but in West Africa draught animals are often used for between-row weeding and ridging. Herbicides are sometimes applied.

Cotton has a very good nutrient uptake ability, and nutrient requirements are therefore moderate. The uptake of a crop producing 1680 kg/ha seed cotton has been estimated at 105 kg N, 18 kg P and 66 kg K per ha. With the seed cotton 40 kg N, 7 kg P and 14 kg K per ha are removed; with the crop residues (especially the leaves) 65 kg N, 11 kg P and 52 kg K per ha are removed. Half the N and all P and K are usually applied around sowing. The second application of N is given about a month after sowing, at final thinning. Too much N stimulates vegetative growth and extends the vegetative period, whereas N-shortage leads to chlorosis, reduced growth and boll-shedding. *Gossypium barbadense* is more sensitive to excess N than *Gossypium hirsutum*. Sufficient K is important for cotton fibre quality and disease resistance and shortage leads to mottled yellowish leaves with brown concentric spots, with the leaf margins drying and curling inwards, and the leaves eventually drying out and being shed. P-deficiency results in dark green leaves and delayed flowering and fruiting.

Gossypium barbadense is more often grown with irrigation than *Gossypium hirsutum*. Under rainfed conditions supplemental irrigation may help early planting and alleviate dry spells in mid season. To stop vegetative development, irrigation should cease shortly after boll opening has started.

Cotton can be grown as a perennial and be cut back and ratooned, but this is not advisable, because perennial cotton can act as a host reservoir for cotton pests and diseases.

Diseases and pests Diseases are less important in cotton than pests. The most widespread diseases are bacterial blight, leaf spot, blackarm or boll rot caused by *Xanthomonas axonopodis* pv. *malvacearum* (synonym: *Xanthomonas campestris* pv. *malvacearum*), anthracnose caused by *Glomerella gossypii* (anamorph: *Colletotrichum gossypii*), Fusarium wilt caused by *Fusarium oxysporum*, and Verticillium wilt caused by *Verticillium dahliae*. Bacterial blight is controlled by growing cotton only once every 3 or more years on the same field, removing the harvest remains and seed treatment. Anthracnose can be controlled by the same measures, but resistant cultivars are not available. *Gossypium barbadense* cultivars with resistance against Fusarium wilt and Verticillium wilt are available. Cropping methods to control wilt diseases include crop rotation, sufficient K-fertilization and the control of nematodes. The most important virus diseases of cotton in tropical Africa are leaf curl, African cotton mosaic and cotton blue disease. Virus diseases are controlled by eliminating reservoir hosts and vectors, and by using tolerant or resistant cultivars.

Cotton suffers from a wide spectrum of pests. Bollworms are among the most serious pests. They feed inside the bolls, damaging lint and seed and so causing considerable reduction in yield and quality. The main bollworms are American bollworm (*Helicoverpa armigera*), pink bollworm (*Pectinophora gossypiella*) and spiny bollworm (*Earias* spp.). Spiny bollworm, to which *Gossypium arboreum* and *Gossypium barbadense* seem less susceptible than *Gossypium hirsutum*, has a serious early effect of tipboring in the main stem leading to excessive formation of vegetative branches and delaying the setting of bolls, which makes them vulnerable to mid-season American bollworm and stainers. Resistance to bollworms has not been achieved to the desired extent, and their control has long relied heavily on insecticides.

Leaf, stem and bud-sucking bugs can cause considerable damage. Jassids (*Amrasca*, *Empoasca*, *Erythroneura*, *Jacobiella* and *Jacobisca* spp.) are the first pests to appear, but a dense coating of long hairs on leaves and stems provides good protection. Whitefly (*Bemisia tabaci*) and cotton aphid (*Aphis gossypii*) are pests later in the season; the former is the vector of leaf curl and African cotton mosaic, the latter of cotton blue disease. Early sowing, weeding and harvesting and the use of short-season cultivars can reduce their damage. Cotton stainers (*Dysdercus* spp.) occur in all cotton-growing countries. They pierce the green bolls and inject the fungus *Nematospora gossypii*, which causes yellow staining of the lint, resulting in lower quality. About 4 alternating sprays of organophosphates and pyrethroids can overcome this pest. Fairly effective preventive control can be obtained by strict phytosanitation, early cropping of maize or sorghum followed by early ploughing and close planting of cotton using an early-maturing cultivar. The boll weevil (*Anthonomus grandis*) is economically the most serious cotton pest in the United States. Close relatives of cotton, such as *Abuti-*

lon species growing nearby are alternative hosts of cotton pests, especially stainers.

Insect pests in cotton have been effectively controlled since 1945 with the use of insecticides. The repeated development of resistance of insect pests (especially the American bollworm) to new insecticides has in some countries led to excessive spraying, up to 15 sprays per season, killing all natural enemies. This may also induce outbreaks of previously minor pests, requiring additional spraying. To reduce the use of pesticides, the application of Integrated Pest Management (IPM) or Integrated Weed and Pest Management (IWPM) is advocated. Very early field preparation including repeated weeding, fertilizer application, early planting of jassid-resistant cultivars, gapping, thinning and judicious use of pesticides on the basis of insect monitoring and damage thresholds, form the basis of interacting IWPM farming practices. Preventive weed control by ploughing or hoeing promptly after clearing the preceding crop stores moisture from unexpected storms in the subsoil which makes it possible to plant early. This encourages early fruiting well ahead of the main pest, American bollworm, and provides ample time for compensatory fruiting in case of early fruit damage. As insecticides against jassids are no longer needed they do not kill the natural enemies which control American bollworm in its vulnerable young stage. By the time the later pink bollworms, stainers and whitefly occur, the main crop will be safe.

The most widely distributed economically important nematode in cotton is the root-knot nematode (*Meloidogyne* spp.), whereas the reniform nematode (*Rotylenchus* spp.) is more restricted to tropical and subtropical environments. *Gossypium arboreum*, *Gossypium herbaceum* and *Gossypium barbadense* are less susceptible to the reniform nematode than *Gossypium hirsutum*. Nematodes can be controlled by rotation and chemicals, whereas cotton genotypes have been developed with some tolerance to the reniform nematode.

Harvesting In tropical Africa cotton harvesting is generally done by hand, usually in 3 rounds, because leaving open bolls in the field may result in deterioration of lint quality. The first picking starts about 10 days after the fruits have opened, the other rounds follow at intervals of a little over 1 week. The cotton should be sorted right away during harvesting into white cotton, stained cotton and waste. At harvesting, the cotton must be as dry as possible. In forest regions and in the event of late rains, additional drying on racks may be necessary. Hand-picking gives cleaner cotton and a higher recovery than mechanical harvesting.

Mechanical harvesting is practised in the United States and Australia, where hand-picking is too expensive; here low-growing, weakly-branching cultivars are sown at narrow spacings, and plants are sprayed with defoliants before harvesting. Mechanically harvested fibre needs heating and shaking to remove impurities, and this operation makes the fibre more brittle.

After picking, the seed cotton is cleaned and transported in bags or sheets to the ginnery for checking, weighing, sorting and payment. The seed from the first ⅓ of the crop picked is usually the most viable and may be kept separately in clearly marked bags. The lint from the first ⅔ of the crop is the most mature and strong.

After the cotton has been harvested, the cotton stems should be uprooted and burnt to prevent the build-up of pest and diseases.

Yield A seed cotton yield of up to 4 t/ha is possible under optimal conditions, but in practice it is seldom over 2.5 t/ha and the average world yield is about 2 t/ha. In most tropical African countries the yield is around 1 t/ha. Seed cotton of primitive cultivars yields 20–25% fibre after ginning, whereas good cultivars of upland cotton have a 'ginning-outturn' of at least 35% and sometimes over 40%. The yields of *Gossypium barbadense* are relatively low, compared to those of *Gossypium hirsutum*.

Handling after harvest In most tropical African countries, the harvested cotton is marketed through national agencies, but in some countries (Nigeria, Kenya) it is done in collaboration with the private sector. In the case of national structures, yield forecasts are made by extension workers, to enable the mobilization of sufficient transport and processing facilities. In most countries the harvested cotton is separated into clean seed cotton and stained or trashy seed cotton.

Cotton lint is removed from the seeds by ginning, which can be done with a hand gin (capacity of 2–3 kg lint/hour) or mechanically. Mechanical ginning can be done with a saw gin (capacity of 300 kg lint/hour) for the shorter stapled cottons, or with the more gentle roller gin (capacity of 30 kg lint/hour) for the longer stapled fine types. In some African countries, such as Kenya and Uganda, roller ginning is common, even for shorter stapled cotton. In

West and Central Africa manual ginning may be done by placing the seed cotton on a block of wood or a flat stone, and squeezing out the seeds by rolling an iron or wooden rod over it. The optimum moisture content of the fibre for ginning is 5–7%. When the moisture content is lower, excessive fibre damage occurs; when it is higher, the amount of broken seeds is higher. The ginning outturn (the fibre weight as a percentage of the weight of the seed cotton) ranges from 44% in Côte d'Ivoire to 28–35% in DR Congo. After ginning, the fibres are pressed into bales of 216 kg and the seeds are transported to the oil mill.

Cotton fibre quality is defined in terms of its length and uniformity, strength, elasticity and maturity, whereas whiteness and trash content also play a role. These properties can all be measured rapidly by the 'High Volume Instrument' (HVI).

At the oil mill, fuzz is removed by additional saw ginning before seeds are crushed. The oil is usually extracted mechanically in a screw press, or chemically with a solvent.

Genetic resources The Cotton Germplasm Collection of the United States Department of Agriculture, Agricultural Research Service (USDA/ARS) at College Station in Texas, United States, contains about 1600 accessions of *Gossypium barbadense*. The Brazilian Agricultural Research Corporation (EMBRAPA) maintains the Brazilian collection with about 1500 *Gossypium barbadense* accessions. In Uzbekistan the Cotton Breeding Institute, the Institute of Genetics and Plant Experimental Biology and the National University of Uzbekistan together hold about 1300 *Gossypium barbadense* accessions. In Russia the N.I.Vavilov Institute of Plant Industry (VIR) in St Petersburg holds about 1100 accessions of *Gossypium barbadense*. The cotton collection of the Chinese Academy of Agricultural Sciences (CAAS) kept in Beijing, Anyang and Hainan Island, contains about 600 *Gossypium barbadense* accessions. In India about 500 *Gossypium barbadense* accessions are kept at the Central Institute for Cotton Research (CICR) in Nagpur and Coimbatore, and the National Bureau for Plant Genetic Resources (NBPGR) in New Delhi. The genebank of the Centre de Coopération Internationale en Recherche Agronomique pour le Développement (CIRAD) at Montpellier, France, also contains about 500 accessions of *Gossypium barbadense*.

Breeding Until the 1930s cotton breeding was limited to crossing within the diploid and tetraploid groups. After this, polyploidization of the diploids greatly increased breeding opportunities. Crosses between Old World and New World genotypes have become important, especially for resistance breeding and the breeding of better cultivars for regions in Asia where *Gossypium arboreum* and *Gossypium herbaceum* grow well, but *Gossypium hirsutum* does not. F1 hybrid cultivars with considerable hybrid vigour for yield have been successfully developed. However, the available systems of cytoplasmic male sterility have been inadequate for large-scale production of hybrid seed, mainly due to incomplete expression of fertility restorer genes in the male parents. Current use of cotton hybrids is limited to South Asia and China, where seed production by manual emasculation and pollination is economically feasible because of low labour costs.

The main objectives in cotton breeding, apart from higher yields, are photoperiod-insensitivity, early maturity, adaptation to mechanical harvesting (through low growth, little branching, short flowering period, loosely attached seeds, less hairy leaves), fibre quality (length, fineness, strength and elasticity), seed quality (high oil content and low gossypol content, increased suitability of the presscake as a source of protein for humans and animals), resistance to diseases (e.g. bacterial blight and Fusarium wilt) and pests (e.g. bollworms, jassids) and tolerance to drought, cold and salinity. There has been little progress in breeding for pest resistance (except for resistance to jassids), but much success has been obtained in resistance and tolerance to Fusarium and Verticillium wilts, bacterial blight and nematodes.

Modern *Gossypium barbadense* cultivars are highly introgressed with *Gossypium hirsutum*, and most commercial *Gossypium barbadense* cultivars have 8–12% *Gossypium hirsutum* DNA.

Prospects Cotton will remain very important on a worldwide scale, because of its excellent fibre properties and low price. Although *Gossypium barbadense* yields high-quality fibre (longer and stronger than that of *Gossypium hirsutum*), the largest part of the world cotton production comes from *Gossypium hirsutum*, because *Gossypium barbadense* needs longer to mature than *Gossypium hirsutum*, gives lower yields and is more sensitive to suboptimal growing conditions. This situation is unlikely to change much, although it must be added that the distinction between the 2 species becomes more and more blurred as a result of natural and artificial hybridization and gene transfer.

Major references Anonymous, 2008; Burkill, 1997; Campbell et al., 2010; Fryxell, 1978; Hau, Lançon & Dessauw, 1997; Kerhoven & Mutsaers, 2003; Peeters et al., 2001; Percy, 2009; Percy, Calhoun & Kim, 1996; Smith & Cothren (Editors), 1999; Verdcourt & Mwachala, 2009.

Other references Adjanohoun et al. (Editors), 1988; Adjanohoun et al., 1989; Akoègninou, van der Burg & van der Maesen, 2006; ECOCROP, 2007b; Hasrat, Pieters & Vlietinck, 2004; Hauman & Wouters, 1963; Hutchinson, 1962; Inngjerdingen et al., 2004; Jarman, 1998; Keay, 1958d; Khafaga, 1983; Kirk & Higginbotham, 1999; Latham, 2005; Lopes & Steidle Neto, 2011; Markström, 1977; Raponda-Walker & Sillans, 1961; Roecklein & Leung (Editors), 1987; Seignobos & Schwendiman, 1991; Unruh & Silvertooth, 1996; Wise, Sassenrath-Cole & Percy, 2000.

Sources of illustration Purseglove, 1968.

Authors G. Todou & S. Konsala

Based on PROSEA 17: Fibre plants.

GOSSYPIUM HERBACEUM L.

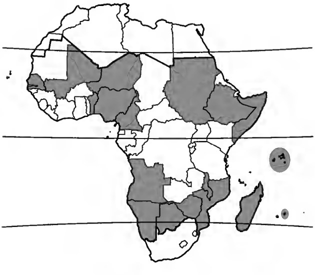
Protologue Sp. pl. 2: 693 (1753).

Family Malvaceae

Chromosome number $2n = 26$

Vernacular names Cotton, Arabian cotton, Levant cotton (En). Coton, cotonnier, cotonnier herbacé, cotonnier d'Asie, cotonnier africain (Fr). Algodoeiro, algodoeiro asiático (Po).

Origin and geographic distribution *Gossypium herbaceum* originated in southern Africa but was first domesticated in Arabia, from where cultivated forms spread westward to Africa and eastward to India. At present it is cultivated in Africa and Asia, and sometimes planted in the New World.



Gossypium herbaceum – wild and planted

In this article the word 'cotton' refers to information referring to all 4 cultivated *Gossypium* species (*Gossypium arboreum* L., *Gossypium barbadense* L., *Gossypium herbaceum* and *Gossypium hirsutum* L.); where information refers to *Gossypium herbaceum* only, this is stated explicitly.

Uses Cotton is the most important group of fibre plants in the world. The main fibres of cotton plants are the longer seed hairs ('lint'), used for making yarn to be woven into textile fabrics, alone or in combination with other plant, animal or synthetic fibres. Cotton lint is also made into other products including sewing thread, cordage and fishing nets. Cotton textile cuttings and rags serve in the paper industry for the production of the best writing, book and drawing paper. Short fibres ('fuzz' or 'linters') are processed into a range of products, including papers, twine, automobile upholstery, explosives, plastics and photographic film. Linter pulp is made into various types of paper, depending on its grade. Linters have also been used for the production of cellulose acetate and viscose. Cotton stalks are processed into paper and paperboard, for instance in China, and into cement-bonded particle board.

Oil obtained from cotton seed is industrially used in a range of products, including margarine, mayonnaise, salad and cooking oils, salad dressing and shortening. It is also made into soap, cosmetics, lubricants, sulphonated oils and protective coatings. Locally it serves for cooking and frying. Blends of cotton-oil biodiesel and diesel fuel can be used in conventional diesel engines without any major changes. The seed cake remaining after oil extraction is an important protein concentrate for livestock. Low-grade cake is used as manure. The whole seed can be fed to ruminants, which are less sensitive to the toxic gossypol in the seed than non-ruminants, or is applied as manure. Hulls are a low-grade roughage for livestock or serve as bedding or fuel. Leftover bolls, leaves and thin twigs are grazed by ruminants. Dry stalks serve as household fuel.

In tropical Africa *Gossypium herbaceum* has largely been replaced by *Gossypium hirsutum* and *Gossypium barbadense* as a source of cotton fibre, and its fibre is not much used nowadays. In Namibia the fibres of wild plants are used in cleaning pads, they are placed into quivers to separate arrows, and are used for placing medicines into the ears. In Zimbabwe spinning and weaving of wild *Gossypium herbaceum* fibre was practised up to 1940, but the practice seems to have died out. In the Lake Chad area of Nigeria *Gossypium herbaceum* is planted to demarcate fields.

Gossypium herbaceum is widely used in traditional African medicine, especially root preparations. In Senegal a root maceration is given to new-born babies and sickly or rachitic children, to strengthen them. In Somalia a root decoction is drunk as an abortifacient. In Ethiopia the root is chewed in case of a snake bite. In Namibia the powdered root bark is applied as a haemostatic. In Botswana root preparations are used for the treatment of heart palpitations. In Mozambique root decoctions are drunk as a tonic and to control vomiting, an infusion of the root against lack of appetite, an infusion of the roots of *Gossypium herbaceum* and *Maclura africana* (Bureau) Corner to purify mother milk, and an infusion of the roots of *Gossypium herbaceum* and a *Cynodon* species to prevent abortion. The stem juice is applied against otitis in the Seychelles. The juice of the heated unripe fruit is dropped into the ear against earache in Somalia, while in Ethiopia the powdered fruit is applied on the head for the treatment of fungal infections.

Production and international trade According to FAO estimates the annual world cotton production in 2004–2008 was about 70 million t seed cotton (unginned cotton, containing seed, lint and fuzz), from 34 million ha. However, the largest part (more than 90%) of the world cotton production comes from *Gossypium hirsutum*, which is highly productive and shows strong yield responses to improved growing conditions, fertilizers, crop protection and supplementary irrigation. Most of the remainder comes from *Gossypium barbadense*. *Gossypium herbaceum* accounts for less than 1% of world cotton fibre production. In 2005, the total planted area of *Gossypium herbaceum* was about 770,000 ha, of which 98% in India. In tropical Africa *Gossypium herbaceum* is grown for domestic use only.

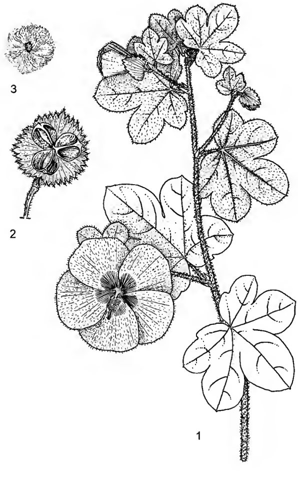
Properties Cotton fibres are unicellular extensions of epidermis cells of the seed. Two types of fibres are distinguished: long fibres ('lint') and short fibres ('fuzz' or 'linters'). Cotton lint fibres are 10–40(–64) mm long, with a diameter of (12–)18–28(–42) μm and a length:width ratio of 1000–4000. The lint fibres of *Gossypium herbaceum* are (10–)20–25 mm long and mostly coarse, although very fine fibres also occur and are processed into handmade, decorative traditional textiles (the 'woven winds of India'). In general, the fibres of *Gossypium herbaceum* are shorter, coarser and weaker than those of *Gossypium hirsutum* and *Gossypium barbadense*. Fuzz fibres are similar in appearance to lint fibres, but shorter (2–7 mm long), more cylindrical and with thicker walls.

Apart from fibre length and its uniformity, the most important properties of cotton are fineness (diameter), maturity, strength and elasticity. The combined fineness and maturity (the degree to which the secondary cell wall has developed) of cotton fibre is usually determined by resistance to air flow, and expressed in a value called 'micronaire', reflecting the linear density of fibres. Typical values of the tensile strength, elongation at break, and Young's modulus of cotton fibre are 285–595 N/mm^2, 7.0–8.0% and 5500–12,600 N/mm^2, respectively. Among the world's major textile fibres, cotton has a unique combination of properties, being strong, comfortable, washable, durable and printable. It also blends well with other fibres to give it additional strength, lustre and crease resistance. On a dry weight basis, cotton fibre contains 88–96% α-cellulose, 3–6% hemicelluloses and 1–2% lignin.

Cotton seeds remaining after ginning consist of linters (5–10%), oil (15–33%), oilcake (33–45%) and hulls (24–34%). Cottonseed oil is a semi-drying oil obtained by mechanical and/or solvent oil extraction from the seed. The principal fatty acids in cottonseed oil are linoleic acid (42–59%), palmitic acid (20–34%) and oleic acid (13–25%). The oil of 4 *Gossypium herbaceum* cultivars from India mainly contained linoleic acid (48–54%), palmitic acid (22–27%) and oleic acid (20–22%). The seed oil also contains 0.5–1(–2)% cyclopropenoid fatty acids, which are known to cause physiological disorders in animals. The oil as well as other plant parts of *Gossypium* species contain gossypol, a triterpenoid aldehyde, which is toxic to humans and animals, monogastric animals in particular. Gossypol has insecticidal, antimicrobial, antifertility and antitumour properties. Gossypol and related compounds have been implicated in conferring insect tolerance or resistance and antimicrobial properties to cotton plants. Glandless, gossypol-free cultivars exist, but they are more vulnerable to pests. Gossypol can be removed from the oil by solvent extraction, following mechanical and/or solvent oil extraction from the seed. The cake and meal contain over 40% crude protein, but are not without danger for monogastric animals, because of the gossypol they contain. The gossypol in the cake can be removed or made harmless by chemical (ferrous salts) or physical (heating) means, but this is more difficult to achieve economically than removing gossypol from the oil.

Methanol leaf extracts of *Gossypium herbaceum* have shown antibacterial activity against *Bacillus megaterium*, *Escherichia coli*, *Klebsiella* sp., *Proteus vulgaris*, *Pseudomonas fluorescens* and *Sorcina lutea*, while petroleum ether, benzene, chloroform and acetone extracts were inactive against most bacteria.

Description Perennial or annual shrub or subshrub up to 3 m tall, with few branches and nearly all parts irregularly dotted with black oil glands; stem thick and rigid, stem and branches hairy or glabrous. Leaves spirally arranged; stipules small, linear, caducous; petiole 2–3.5 cm long; blade 3–7-lobed, cut less than halfway, 2–6 cm × 2–7 cm, base cordate, lobes ovate to rounded, only slightly constricted at the base, upper surface glabrescent, lower surface stellate hairy, glands present on midvein beneath. Flowers solitary, usually on sympodial branches; pedicel 7–30 mm long, not articulated, glandless; epicalyx segments (bracteoles) 3, flaring widely from the flower and the fruit, rounded or broadly triangular, usually wider than long, cordate at base, margin with 5–13 triangular teeth, persistent; calyx 5–10 mm long; corolla yellow or white with a dark centre, petals 5, 2.5–5 cm long; stamens numerous, forming a antheriferous column throughout, filaments short, anthers 1-celled; pistil with 3–5-celled ovary and one short style, stigma entire, rarely cleft at the top. Fruit ('boll') a rounded capsule 2–3.5 cm long, beaked, surface smooth or very shallowly dented, with few oil glands, 3–4-valved, opening slightly when ripe, with up to 11 seeds per valve. Seed ovoid, with a dense covering of long, pure white, woolly hairs (lint or floss) and sometimes also with a fine, short tomentum (fuzz), strongly attached to the seed. Seedling with epigeal germination.



Gossypium herbaceum – 1, flowering branch; 2, dehisced fruit; 3, seed.
Redrawn and adapted by H. de Vries

Other botanical information *Gossypium* comprises about 50 species distributed in warm temperate to tropical zones. The origin of the genus is unknown, but 3 primary centres of diversity exist: in Australia, in north-eastern Africa to Arabia, and in western-central to southern Mexico. The 4 cultivated cottons of the world (the Old World diploids *Gossypium arboreum* and *Gossypium herbaceum* and the New World tetraploids *Gossypium barbadense* and *Gossypium hirsutum*) have been domesticated independently in different parts of the world. The taxonomy of *Gossypium* is complicated, partly due to the domestication of 4 distinct species and extensive interspecific hybridization. The literature is confusing and authors disagree on the identity of many species, subspecies, sections, varieties, forms, races and cultivars that have been distinguished. Currently the taxonomic system of P.A. Fryxell, with about 50 species grouped into 4 subgenera and 8 sections, is the most generally accepted one. It is mainly based on morphological and geographical data, but is confirmed by cytogenetic and molecular evidence. Cytological research has led to the recognition of 8 basic diploid 'genomic groups', designated A through G, plus K. In general, species within a genomic group can form fertile interspecific hybrids. *Gossypium herbaceum* and *Gossypium arbo-*

reum are included in subgenus *Gossypium*: diploid Old World species with A-genome, whereas *Gossypium barbadense* and *Gossypium hirsutum* belong to subgenus *Karpas*: tetraploid New World species with AD-genome.

Gossypium herbaceum is subdivided into 2 subspecies:

- subsp. *africanum* (Watt) Vollesen (synonym: *Gossypium herbaceum* L. var. *africanum* (Watt) Hutch. & R.L.M.Ghose), the wild form: perennial shrub, stem and petiole without long simple hairs, sometimes with stellate hairs with long branches, stipules 3–8(–9) mm long, calyx ciliate, and fruit 15–20(–25) mm long; it is distributed in Angola, Namibia, Botswana, Zimbabwe, Mozambique, South Africa and Swaziland, and is considered the ancestor of the cultivated forms of *Gossypium herbaceum*.
- subsp. *herbaceum*, comprising the cultivated forms: perennial or annual shrubs, stem and petiole with long simple hairs, stipules (6–) 9–15 mm long, calyx only rarely ciliate, and fruit 20–32 mm long.

Subsp. *herbaceum* is subdivided into 4 races:

- acerifolium: large, rounded, many-branched shrubs with small bolls, in which the seeds are sparsely covered with coarse lint; the most primitive cultivated form of *Gossypium herbaceum*; probably domesticated in Ethiopia or southern Arabia and from there spread to West Africa; in tropical Africa formerly the main cultivated cotton from Gambia to Ethiopia, but replaced by *Gossypium hirsutum* and *Gossypium barbadense* and only persisting in relict cultivations.
- kuljianum: annual, very small, slender, sparsely branched subshrubs, with small bolls and scanty lint of low quality; early maturing, selected for regions with short, hot summers and long, cold winters; mainly cultivated in Russia and western China.
- persicum: annual, small, sparsely branched, stout subshrubs, with large, round bolls and copious lint of moderate quality; adapted to regions with a relatively cool winter season; initially spread around the Mediterranean, this was the first cotton cultivated in the Nile delta, later it also spread eastward through Iraq to Turkmenistan and Afghanistan.
- wightianum: annual, large, stout, moderately branched shrubs, with large bolls and copious lint of high quality; cultivated in Iran and western India.

Anatomy Cotton lint fibres are smooth-looking, ribbon-like and twisted, with the fibre walls showing longitudinal and spiral striations. The fibre walls contain many layers of cellulose chains, which run spirally and give dry fibres their characteristic twisting appearance. The hairs are covered with a waxy cuticle, giving unprocessed fibre a greasy feel and making it water-repellent.

Growth and development *Gossypium* spp. are normally perennial plants with an indeterminate growth habit, but are usually grown as annuals, with the formation of nodes on the main stem stopped by fruit load, temperature, soil moisture, photoperiod, or a combination of these factors. The crop cycle is 120–220 days. Seedlings emerge 5–15(–30) days after sowing and the first true leaf unfolds 7–9 days later, but these processes vary with temperature. Upon germination, seedlings initiate a long taproot, which can reach a depth of more than 25 cm by the time the cotyledons unfold and may reach a depth of 3 m by mid-season. The shoot system is dimorphic, with the main axis and lower branches (emerging from axillary buds) being monopodial and vegetative, whereas the fruiting branches (emerging from extra-axillary buds) are sympodial. Fruiting branches develop as primary branches higher on the main stem and as secondary branches on vegetative branches. Generally only one fruiting branch develops at each node, with 3–5 fruits per branch. The first fruiting branch appears at node 4–5 of the main stem, between 1 and 2 months after sowing, and visible flower buds appear as small, green, pyramidal structures, known as 'squares'. They need 20–35 days to develop into open flowers. The flowers mostly open near dawn and pollination normally occurs within a few hours. Self-pollination is the predominant mating system, but visiting insects can cause considerable outcrossing (up to 40%). Flowering peaks at 3(–6) weeks after the onset and may continue for about 6 weeks. The fruits grow very quickly after pollination, reaching their final size at about 20–25 days. After a further (20–)25–45(–60) days, depending on genotype and environmental conditions, they are ripe. Usually the dry fruits open at their sutures and the white, fluffy fibre-mass emerges. The seeds remain attached to the placenta and are only separated by picking or by very strong rain or wind.

During the first 2–4 weeks after flowering (the elongation phase) the fibres grow rapidly, reaching their full length, and during the next 4–6 weeks (the secondary thickening phase) the cell walls of the fibres thicken through deposition of cellulose in consecutive layers. The cell wall thickness of a fibre, or the degree to which the fibre has been filled with cellulose, mainly depends on plant vigour during ripening. Upon boll opening the fibre dries and the lumen collapses, resulting in the characteristic twisted, ribbon-like appearance of the fibre that makes it spinnable.

Shedding of squares and young bolls is common in cotton. It is aggravated by adverse conditions such as prolonged overcast weather, extreme temperatures, water stress, waterlogging, nutrient deficiencies, diseases and insect damage. Commonly 60% of the squares and young bolls are shed, but flowers are rarely shed. The ability to overcome adverse events by compensatory growth is characteristic for cotton. However, recovery is only partial and insignificant when severe insect damage occurs late in the season.

Ecology *Gossypium herbaceum* requires a temperature of (18–)26–36(–38)°C and a rainfall of (200–)750–1250(–1500) mm during the growing season. It can be grown on medium to deep, light to heavy, well-drained soils with a moderate fertility and a pH of (5.3–)6–7.2(–8.5). It is usually cultivated in marginal, drought prone environments of Asia due to its inherent ability to withstand drought. In tropical Africa it occurs from sea-level up to 1200 m altitude.

Propagation and planting Cotton is propagated by seed. The 1000-seedweight of *Gossypium herbaceum* is 30–60 g. In India *Gossypium herbaceum* is grown in rows 60–260 cm apart.

It is possible to propagate cotton vegetatively by cuttings, budding or grafting. The development of rapid, reproducible and genotype-independent systems of in-vitro propagation of *Gossypium* species been difficult, though methods have now been developed to produce large numbers of somatic embryos from callus from hypocotyl or cotyledon explants of *Gossypium arboreum*, *Gossypium barbadense*, *Gossypium herbaceum* and *Gossypium hirsutum*.

Management Cotton can be grown as a perennial and be cut back and ratooned. Growing cotton species as perennials was formerly very common, but it has been discouraged, because perennial cotton can act as a host reservoir for cotton pests and diseases. Locally, for instance in Cameroon, fields with perennial cotton plants can still been seen.

Diseases and pests Diseases are less important in cotton than pests. The most widespread diseases are bacterial blight, leaf spot, blackarm or boll rot caused by *Xanthomonas axonopodis* pv. *malvacearum* (synonym: *Xanthomonas campestris* pv. *malvacearum*), anthracnose caused by *Glomerella gossypii* (anamorph: *Colletotrichum gossypii*), Fusarium wilt caused by *Fusarium oxysporum*, and Verticillium wilt caused by *Verticillium dahliae*. Before resistance was found and incorporated in *Gossypium hirsutum* cultivars, bacterial blight caused seed cotton yield losses up to 28% in African cotton crops, and it is considered partially responsible for the sustained cultivation of *Gossypium arboreum* and *Gossypium herbaceum* in Africa and Asia. Bacterial blight is controlled by growing cotton only once every 3 or more years on the same field, removing the harvest remains and seed treatment. Anthracnose can be controlled by the same measures, but resistant cultivars are not available. Cropping methods to control wilt diseases include crop rotation, sufficient K-fertilization and the control of nematodes. The most important virus diseases of cotton in tropical Africa are leaf curl, African cotton mosaic and cotton blue disease. Virus diseases are controlled by eliminating reservoir hosts and vectors, and by using tolerant or resistant cultivars.

Cotton suffers from a wide spectrum of pests. Bollworms are among the most serious pests. They feed inside the bolls, damaging lint and seed and so causing considerable reduction in yield and quality. The main bollworms are American bollworm (*Helicoverpa armigera*), pink bollworm (*Pectinophora gossypiella*) and spiny bollworm (*Earias* spp.). Spiny bollworm has a serious early effect of tipboring in the main stem leading to excessive formation of vegetative branches and delaying the setting of bolls, which makes them vulnerable to mid-season American bollworm and stainers. Resistance to bollworms has not been achieved to the desired extent, and their control has long relied heavily on insecticides.

Leaf, stem and bud-sucking bugs can cause considerable damage. Jassids (*Amrasca*, *Empoasca*, *Erythroneura*, *Jacobiella* and *Jacobisca* spp.) are the first pests to appear, but a dense coating of long hairs on leaves and stems provides good protection. Whitefly (*Bemisia tabaci*) and cotton aphid (*Aphis gossypii*) are pests later in the season; the former is the vector of leaf curl and African cotton mosaic, the latter of cotton blue disease. Whitefly (*Bemisia tabaci*) and cotton aphid (*Aphis gossypii*) are pests later in the season. Early sowing, weeding and harvesting and the use of short-season cultivars can reduce their damage. Cotton stainers (*Dysdercus* spp.) occur in all cotton-growing countries. They pierce the green bolls and inject the fungus *Nematospora gossypii*, which causes yellow staining of the lint, resulting in lower quality. About 4 alternating sprays of organophosphates and pyrethroids can overcome this pest. Fairly effective preventive control can be obtained by strict phytosanitation, early cropping of maize or sorghum followed by early ploughing and close planting of cotton using an early-maturing cultivar. Close relatives of cotton, such as *Abutilon* species growing nearby are alternative hosts of cotton pests, especially stainers.

Insect pests in cotton have been effectively controlled since 1945 with the use of insecticides. The repeated development of resistance of insect pests (especially the American bollworm) to new insecticides has in some countries led to excessive spraying, up to 15 sprays per season, killing all natural enemies. This may also induce outbreaks of previously minor pests, requiring additional spraying. To reduce the use of pesticides, the application of Integrated Pest Management (IPM) or Integrated Weed and Pest Management (IWPM) is advocated. Very early field preparation including repeated weeding, fertilizer application, early planting of jassid-resistant cultivars, gapping, thinning and judicious use of pesticides on the basis of insect monitoring and damage thresholds, form the basis of interacting IWPM farming practices. Preventive weed control by ploughing or hoeing promptly after clearing the preceding crop stores moisture from unexpected storms in the subsoil which makes it possible to plant early. This encourages early fruiting well ahead of the main pest, American bollworm, and provides ample time for compensatory fruiting in case of early fruit damage. As insecticides against jassids are no longer needed they do not kill the natural enemies which control American bollworm in its vulnerable young stage. By the time the later pink bollworms, stainers and whitefly occur, the main crop will be safe.

The most widely distributed economically important nematode in cotton is the root-knot nematode (*Meloidogyne* spp.), whereas the reniform nematode (*Rotylenchus* spp.) is more restricted to tropical and subtropical environments. *Gossypium arboreum*, *Gossypium herbaceum* and *Gossypium barbadense* are less susceptible to the reniform nematode than *Gossypium hirsutum*. Nematodes can be controlled by rotation and chemicals, whereas cotton genotypes have been developed with some tolerance to the reniform nematode.

Harvesting In tropical Africa cotton harvesting is generally done by hand. After the cotton has been harvested, the cotton stems should be uprooted and burnt to prevent the build-up of pest and diseases.

Yield A seed cotton yield of up to 4 t/ha is possible under optimal conditions, but in practice it is seldom over 2.5 t/ha and the average world yield is about 2 t/ha. In most tropical African countries the yield is around 1 t/ha. Seed cotton of primitive cultivars yields 20–25% fibre after ginning, whereas good cultivars of upland cotton have a 'ginning-outturn' of at least 35% and sometimes over 40%. Some modern *Gossypium arboreum* and *Gossypium herbaceum* cultivars grown in India and China also yield up to 40% lint.

Handling after harvest Cotton lint is removed from the seeds by ginning, which can be done with a hand gin (capacity of 2–3 kg lint/hour) or mechanically. Mechanical ginning can be done with a saw gin (capacity of 300 kg lint/hour) for the shorter stapled cottons, or with the more gentle roller gin (capacity of 30 kg lint/hour) for the longer stapled fine types. In some African countries, such as Kenya and Uganda, roller ginning is common, even for shorter stapled cotton. In West and Central Africa manual ginning may be done by placing the seed cotton on a block of wood or a flat stone, and squeezing out the seeds by rolling an iron or wooden rod over it. The optimum moisture content of the fibre for ginning is 5–7%. When the moisture content is lower, excessive fibre damage occurs; when it is higher, the amount of broken seeds is higher.

Genetic resources In Uzbekistan the Cotton Breeding Institute, the Institute of Genetics and Plant Experimental Biology and the National University of Uzbekistan together hold about 1500 *Gossypium herbaceum* accessions. In Russia the N.I.Vavilov Institute of Plant Industry (VIR) in St Petersburg holds about 300 accessions of *Gossypium herbaceum*. In India about 300 *Gossypium herbaceum* accessions are kept at the Central Institute for Cotton Research (CICR) in Nagpur and Coimbatore, and the National Bureau for Plant Genetic Resources (NBPGR) in New Delhi. The National Collection of Gossypium Germplasm housed at the Southern Plains Agricultural

Research Center (SPARC), College Station, Texas, United States contains about 200 *Gossypium herbaceum* accessions, the genebank of CIRAD (Centre de Coopération Internationale en Recherche Agronomique pour le Développement) at Montpellier, France, 50, and the Iran National Gene Bank (INGB) in Gurgan, Iran, about 40.

Breeding Until the 1930s cotton breeding was limited to crossing within the diploid and tetraploid groups. After this, polyploidization of the diploids greatly increased breeding opportunities. Crosses between Old World and New World genotypes have become important, especially for resistance breeding and the breeding of better cultivars for regions in Asia where *Gossypium arboreum* and *Gossypium herbaceum* grow well, but *Gossypium hirsutum* does not. F1 hybrid cultivars with considerable hybrid vigour for yield have been successfully developed. However, the available systems of cytoplasmic male sterility have been inadequate for large-scale production of hybrid seed, mainly due to incomplete expression of fertility restorer genes in the male parents. Current use of cotton hybrids is limited to South Asia and China, where seed production by manual emasculation and pollination is economically feasible because of low labour costs.

The main objectives in cotton breeding, apart from higher yields, are photoperiod-insensitivity, early maturity, adaptation to mechanical harvesting (through low growth, little branching, short flowering period, loosely attached seeds, less hairy leaves), fibre quality (length, fineness, strength and elasticity), seed quality (high oil content and low gossypol content, increased suitability of the presscake as a source of protein for humans and animals), resistance to diseases (e.g. bacterial blight and Fusarium wilt) and pests (e.g. bollworms, jassids) and tolerance to drought, cold and salinity. There has been little progress in breeding for pest resistance (except for resistance to jassids), but much success has been obtained in resistance and tolerance to Fusarium and Verticillium wilts, bacterial blight and nematodes.

Although *Gossypium herbaceum* is still cultivated in a considerable number of countries, organized breeding efforts on the species are carried out in India only. The genetic improvement programmes in India are aimed at improving the yield potential and fibre quality. *Gossypium herbaceum* is used in genetic and biotechnological studies in many laboratories around the world, mainly as donor species in introgressive breeding to improve tetraploid cotton, especially for disease resistance and insect tolerance.

Prospects Cotton will remain very important on a worldwide scale, because of its excellent fibre properties and low price, but *Gossypium hirsutum* and *Gossypium barbadense* will remain the most important species. The role of *Gossypium herbaceum* will remain marginal, despite it being more tolerant to drought, bacterial blight and various pests. It will remain important, however, in the genetic improvement of *Gossypium hirsutum* and *Gossypium barbadense*.

Major references Burkill, 1997; Hutchinson, 1962; Kerkhoven & Mutsaers, 2003; Kirkpatrick & Rothrock, 2001; Kulkarni et al., 2009; Matthews & Tunstall (Editors), 1994; Neuwinger, 2000; Peeters et al., 2001; SEPASAL, 2011a; Vollesen, 1987.

Other references Adjanohoun et al., 1983a; Campbell et al., 2010; DCD, undated; ECOCROP, 2007c; Gordon & Hsieh, 2007; Hanelt & Institute of Plant Genetics and Crop Plant Research (Editors), 2001; InDG, 2011; Keay, 1958d; Lewin, 2007; Maite, 1987; Malla Reddy, Reddy & Reddy, 1981; Pandey & Suri, 1982; Patel et al., 2002; Ribeiro et al., 2010; Seignobos & Schwendiman, 1991; Teklehaymanot, 2009; Teklehaymanot & Giday, 2007; Thulin, 1999a; Vollesen, 1995a; Zohary & Hopf, 2000.

Sources of illustration Exell & Meeuse, 1961.

Authors L. Jimu

Based on PROSEA 17: Fibre plants.

GOSSYPIUM HIRSUTUM L.

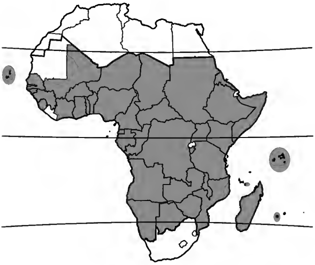
Protologue Sp. pl. ed. 2, 2: 975 (1763).

Family Malvaceae

Chromosome number $2n = 52$

Vernacular names Cotton, upland cotton, American cotton, American upland cotton, green seed cotton (En). Coton, cotonnier, coton velu, cotonnier américain (Fr). Algodoeiro, algodoeiro americano (Po). Pamba (Sw).

Origin and geographic distribution *Gossypium hirsutum* is primarily known from cultivation, but wild forms exist as well. It probably originated as a cross between *Gossypium herbaceum* L. and *Gossypium raimondii* Ulbrich or *Gossypium gossypioides* (Ulbrich) Standley in southern Mexico and was domesticated in Central America or northern South America. It



Gossypium hirsutum – planted and naturalized

has become the main cotton of commerce and is widely cultivated throughout the warmer parts of the world, including tropical Africa. It has often escaped and naturalized.

In this article the word 'cotton' refers to information referring to all 4 cultivated *Gossypium* species (*Gossypium arboreum* L., *Gossypium barbadense* L., *Gossypium herbaceum* and *Gossypium hirsutum*); where information refers to *Gossypium hirsutum* only, this is stated explicitly.

Uses Cotton is the most important group of fibre plants in the world, and *Gossypium hirsutum* the most important of the cotton species. The main fibres of the cotton plant are the longer seed hairs ('lint'), used for making yarn to be woven into textile fabrics, alone or in combination with other plant, animal or synthetic fibres. Cotton lint is also made into other products including sewing thread, cordage and fishing nets. Cotton textile cuttings and rags serve in the paper industry for the production of the best writing, book and drawing paper. Short fibres ('fuzz' or 'linters') are processed into a range of products, including papers, twine, automobile upholstery, explosives, plastics and photographic film. Linter pulp is made into various types of paper, depending on its grade. Linters have also been used for the production of cellulose acetate and viscose. Cotton stalks are processed into paper and paperboard, for instance in China, and into cement-bonded particle board.

Oil obtained from cotton seed is industrially used in a range of products, including margarine, mayonnaise, salad and cooking oils, salad dressing and shortening. It is also made into soap, cosmetics, lubricants, sulphonated oils and protective coatings. Locally it serves for cooking and frying. Blends of cotton-oil biodiesel and diesel fuel can be used in conventional diesel engines without any major changes. The seed cake remaining after oil extraction is an important protein concentrate for livestock. Low-grade cake is used as manure. The whole seed can be fed to ruminants, which are less sensitive to the toxic gossypol in the seed than non-ruminants, or is applied as manure. Hulls are a low-grade roughage for livestock or serve as bedding or fuel. Leftover bolls, leaves and thin twigs are grazed by ruminants. Dry stalks serve as household fuel.

Local uses of *Gossypium hirsutum* in tropical Africa include the use of the fibre for stuffing pillows and mattresses. In Nigeria the seeds are ground in cold water to produce paint. In traditional medicine in Benin a decoction of the leaves of *Gossypium hirsutum* and those of *Flueggea virosa* (Roxb. ex Willd.) Voigt is taken for the treatment of intestinal colic, constipation, low blood pressure and asthenia. The powdered seed or a seed decoction is taken against convulsions with fever. In East Africa the root is chewed or a root decoction drunk against stomach-ache.

Production and international trade *Gossypium hirsutum* accounts for more than 90% of the world cotton production. Most of the remainder comes from *Gossypium barbadense*, which produces longer, finer and more expensive fibre than *Gossypium hirsutum* but yields less and shows limited adaptation to most cotton-growing areas. Two other cotton species, *Gossypium arboreum* and *Gossypium herbaceum*, are grown to some extent in Africa and Asia.

According to FAO estimates the annual world cotton production in 2004–2008 was about 70 million t seed cotton (unginned cotton, containing seed, lint and fuzz), from 34 million ha. The main producers were China (20.3 million t seed cotton per year), the United States (10.8 million t), India (10.8 million t), Pakistan (6.3 million t), Brazil (3.7 million t), Uzbekistan (3.7 million t), Turkey (2.3 million t) and Greece (1.1 million t).

The main producing countries in tropical Africa in this period were Burkina Faso (620,000 t per year), Nigeria (503,000 t), Mali (401,000 t), Benin (306,000 t), Zimbabwe (296,000 t), Tanzania (277,000 t), Côte d'Ivoire (236,000 t), Sudan (231,000 t), Cameroon (241,000 t), Mozambique (170,000 t), Chad (163,000 t) and

Zambia (137,000 t).

The world seed cotton production increased by 82% from 1974–1978, when the average world cotton production was about 38 million t. In the same period, the production in West, Central and southern Africa (regions as defined by PROTA) increased, while that in East Africa decreased. The production in West Africa increased by 393%, from 460,000 t in 1974–1978 to 2.3 million t in 2004–2008. In southern Africa the production increased by 94%, from 334,000 t in 1974–1978 to 648,000 t in 2004–2008. The increase in Central Africa was 51%, from 286,000 t in 1974–1978 to 432,000 t in 2004–2008. In East Africa the annual production declined by 21%, from 874,000 t to 686,000 t, mainly because of much lower production in Sudan (from 531,000 t to 231,000 t). The enormous increase in cotton production in West Africa was the result of an increase in the area under cotton (144%, from 928,000 ha to 2.3 million ha) as well as an increase in yields (105%, from 490 kg/ha to 1010 kg/ha).

In 2004–2008 world cotton lint exports amounted to about 8.1 million t per year, with an export value of US$ 10,600 million. The major exporting countries were the United States (3.2 million t per year), Uzbekistan (831,000 t), India (756,000 t), Australia (435,000 t), Brazil (396,000) and Greece (248,000 t). The main exporters of cotton lint in tropical Africa were Mali (203,000 t per year), Burkina Faso (182,000 t), Benin (114,000 t), Côte d'Ivoire (93,000 t), Zimbabwe (91,000 t), Cameroon (85,000 t), Zambia (53,000 t), Tanzania (50,000 t) and Sudan (50,000 t). The main importers in 2004–2008 were China (2.7 million t per year), Turkey (735,000 t), Indonesia (534,000 t), Pakistan (483,000 t), Thailand (423,000 t), Bangladesh (422,000 t) and Mexico (373,000 t). The imports into countries of tropical Africa were generally very small, with Zimbabwe (31,000 t per year) and Mauritius (25,000 t) being the main importers.

The world cottonseed oil production in 2004–2008 averaged 4.8 million t per year. The major producers were China (1.6 million t per year), India (642,000 t), Pakistan (446,000 t), the United States (407,000 t), Uzbekistan (306,000 t), Brazil (259,000 t) and Turkey (235,000 t). In tropical Africa Burkina Faso produced 51,000 t cottonseed oil per year in 2004–2008, Mali 43,000 t, Benin 23,000 t, Sudan 22,000 t, Nigeria 20,000 t, Tanzania 19,000 t, Zimbabwe 17,000 t, Cameroon 17,000 t, Mozambique 12,000 t and Chad 11,000 t. Cottonseed oil exports in 2004–2008 were only about 150,000 t per year, with an export value of US$ 106 million.

Properties Cotton fibres are unicellular extensions of epidermis cells of the seed. Two types of fibres are distinguished: long fibres ('lint') and short fibres ('fuzz' or 'linters'). Cotton lint fibres are 10–40(–64) mm long, with a diameter of (12–)18–28(–42) μm and a length:width ratio of 1000–4000. The lint of *Gossypium hirsutum* is about 20–30 mm long. In international trade, the fibre length or 'staple length' of cotton is expressed in fractions of inches. Fuzz fibres are similar in appearance to lint fibres, but shorter (2–7 mm long), more cylindrical and with thicker walls.

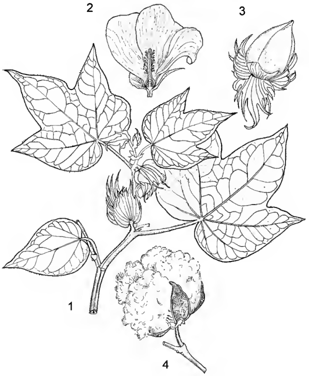
Apart from fibre length and its uniformity, the most important properties of cotton are fineness (diameter), maturity, strength and elasticity. The combined fineness and maturity (the degree to which the secondary cell wall has developed) of cotton fibre is usually determined by resistance to air flow, and expressed in a value called 'micronaire', reflecting the linear density of fibres. Typical values of the tensile strength, elongation at break, and Young's modulus of cotton fibre are 285–595 N/mm^2, 7.0–8.0% and 5500–12,600 N/mm^2, respectively. Among the world's major textile fibres, cotton has a unique combination of properties, being strong, comfortable, washable, durable and printable. It also blends well with other fibres to give it additional strength, lustre and crease resistance. On a dry weight basis, cotton fibre contains 88–96% α-cellulose, 3–6% hemicelluloses and 1–2% lignin.

Stem fibre cells of *Gossypium hirsutum* investigated in Greece were about 0.8 mm long, with a diameter of 18–20 μm, a cell wall thickness of 3–4 μm and a lumen width of 12–13 μm. The stems contained 40–44% α-cellulose and 13–18% lignin.

Cotton seeds remaining after ginning consist of linters (5–10%), oil (15–33%), oilcake (33–45%) and hulls (24–34%). Cottonseed oil is a semi-drying oil obtained by mechanical and/or solvent oil extraction from the seed. The principal fatty acids in cottonseed oil are linoleic acid (42–59%), palmitic acid (20–34%) and oleic acid (13–25%). The seed oil also contains 0.5–1(–2)% cyclopropenoid fatty acids, which are known to cause physiological disorders in animals. The oil as well as other plant parts of *Gossypium* species contain gossypol, a triterpenoid aldehyde, which is toxic to humans and animals, monogastric animals in particular. Gossypol

has insecticidal, antimicrobial, antifertility and antitumour properties. Gossypol and related compounds have been implicated in conferring insect tolerance or resistance and antimicrobial properties to cotton plants. Glandless, gossypol-free cultivars exist, but they are more vulnerable to pests. The gossypol content of *Gossypium hirsutum* seeds (0.51–0.77% of dry matter) is generally lower than that of *Gossypium barbadense* (0.60–1.15%), with a lower proportion of the gossypol present in the more biologically active free form. Gossypol can be removed from the oil by solvent extraction, following mechanical and/or solvent oil extraction from the seed. The cake and meal contain over 40% crude protein, but are not without danger for monogastric animals, because of the gossypol they contain. The gossypol in the cake can be removed or made harmless by chemical (ferrous salts) or physical (heating) means, but this is more difficult to achieve economically than removing gossypol from the oil. It has been suggested that adult cattle should have less than 0.1–0.2% gossypol in the total ration, which would amount to 1.8–2.7 kg of *Gossypium hirsutum* seed per day.
The oil of *Gossypium hirsutum* has shown antibacterial activity against Gram-positive and Gram-negative bacteria, and the antibacterial activity was not affected by fermentation of the oil.

Description Annual herb or perennial shrub up to 3 m tall, usually much branched, with nearly all parts irregularly dotted with black oil glands. Leaves spirally arranged; stipules ovate to lanceolate, often falcate, 5–15(–20) mm × 2–5 mm; petiole 2–10 cm long; blade orbicular in outline, 3–15 cm in diameter, palmately 3-lobed, rarely palmatifid, lower ones sometimes 5-lobed, upper ones occasionally ovate and entire, base cordate, lobes broadly ovate to triangular, apex acute to acuminate, sinuses acute to rounded, margin entire, densely pubescent to glabrous, palmately 5–7-veined, with nectaries on the central basal veins beneath. Flowers solitary, usually on sympodial branches; pedicel 1–4 cm long, not articulated, with 3 nectaries below the insertion of the epicalyx segments; epicalyx segments (bracteoles) 3, free, closely enveloping the flower and fruit, ovate to triangular, 2–6.5 cm × 1.5–4 cm, cordate at base, margin with 3–19 acuminate teeth, persistent; calyx campanulate to cupular, 5–7 mm long and 6 mm in diameter, truncate or with 5 rounded (rarely acuminate) segments, outside with 3 inconspicuous nectaries, ruptured after flowering; corolla usually pale yellow to white, rarely with a purplish centre, petals 5, imbricate, obovate, 2–5.5 cm long; stamens numerous, forming a column 1–2 cm long, filaments 3–4 mm long, anthers 1-celled; pistil with 3–5-celled ovary and one short style with clavate, 3–5-sulcate stigma. Fruit ('boll') an ovoid or globose capsule 2–5 cm × 1–1.5 cm, rostrate at the apex, coarsely pitted, glabrous, opening loculicidally, 3–5-celled with several seeds per cell. Seeds ovoid, 3.5–10 mm long, acute at the hilum, black or brown with a dense covering of white or rusty, long, woolly hairs (lint or floss) and with a fine, short tomentum (fuzz) everywhere or only at the hilum. Seedling with epigeal germination.



Gossypium hirsutum – 1, flowering branch; 2, flower in longitudinal section; 3, fruit; 4, opened fruit.
Source: PROSEA

Other botanical information *Gossypium* comprises about 50 species distributed in warm temperate to tropical zones. The origin of the genus is unknown, but 3 primary centres of diversity exist: in Australia, in north-eastern Africa to Arabia, and in western-central to southern Mexico. The 4 cultivated cottons of the world (the Old World diploids *Gossypium arboreum* and *Gossypium herbaceum* and the New World tetraploids *Gossypium barbadense* and *Gossypium hirsutum*) have been domesticated independently in different parts of the world. The taxonomy of *Gossypium* is complicated, partly due to the domestication of 4 distinct species and extensive interspecific hybridization. The literature is confusing and authors disagree on the identity of many species, subspecies, sections, varieties, forms, races and cultivars that have been distinguished. Currently the taxonomic system of P.A. Fryxell, with about 50 species grouped into 4 subgenera and 8 sections, is the most generally accepted one. It is mainly based on morphological and geographical data, but is confirmed by cytogenetic and molecular evidence. Cytological research has led to the recognition of 8 basic diploid 'genomic groups', designated A through G, plus K. In general, species within a genomic group can form fertile interspecific hybrids. *Gossypium barbadense* and *Gossypium hirsutum* belong to subgenus *Karpas*: tetraploid New World species with AD-genome, whereas *Gossypium arboreum* and *Gossypium herbaceum* are included in subgenus *Gossypium*: diploid Old World species with A-genome.

Several subdivisions of *Gossypium hirsutum* have been proposed, but nowadays usually 7 races are recognized:

- latifolium: annual subshrub with medium-sized to very large bolls, early maturing but with a wide range of day-length sensitivity; cultivated pantropically and commercially the most important cotton group of the world, collectively also called 'upland cotton'.
- marie-galante: perennial, strongly arborescent cotton; cultivars are strongly daylength sensitive; of great agricultural importance and widely distributed in all cotton-growing areas, including Côte d'Ivoire and Ghana, occurring as a large shrub or small tree in compounds and waste places.
- morrilli: stout, upright, profusely branched shrub with a rounded appearance, with small, round bolls; grown in central Mexico.
- palmeri: pyramidally shaped, glabrous shrub with distinctive laciniate leaves, flowering prolifically and bearing numerous small bolls; cultivated in western Mexico.
- punctatum: perennial, slender-stemmed shrub, characterized by leaves with 3 lobes and shallow sinuses, bearing a large number of small bolls having seed with short fibres; mainly occurring in Central America, probably carried from Central America to Senegal in the 17th century, and spread eastwards from there, replacing the Old World cotton (mainly *Gossypium herbaceum*) grown there; nowadays the most widely grown cotton in West Africa.
- richmondi: large, profusely branched, sprawling shrub with bolls of moderate size; grown on the Pacific side of the Isthmus of Tehuantepec (southern Mexico and Guatemala).
- yucatanense: small, much-branched, procumbent or prostrate subshrub, only known wild in undisturbed beach vegetation on the northern coast of the Yucatan Peninsula; bolls small, widely flaring, seeds small, with sparse, coarse, brown lint; agronomically the most primitive group, the only one known to grow wild, intergrading morphologically with race 'punctatum'.

Anatomy Cotton lint fibres are smooth-looking, ribbon-like and twisted, with the fibre walls showing longitudinal and spiral striations. The fibre walls contain many layers of cellulose chains, which run spirally and give dry fibres their characteristic twisting appearance. The hairs are covered with a waxy cuticle, giving unprocessed fibre a greasy feel and making it water-repellent. On drying at maturity the fibres lose their tubular shape and become ribbon-like (kidney-shaped in cross-section), twisting in different directions forming the well-known convolutions. Desiccation at maturity is an irreversible physical process, generating technological properties that make the cotton fibre very suitable for textile production.

Growth and development Cotton is normally a perennial plant with an indeterminate growth habit, but is usually grown as an annual, with the formation of nodes on the main stem stopped by fruit load, temperature, soil moisture, photoperiod, or a combination of these factors. The crop cycle is 120–220 days. Seedlings emerge 5–15(–30) days after sowing and the first true leaf unfolds 7–9 days later, but these processes vary with temperature. Upon germination, seedlings initiate a long taproot, which can reach a depth of more than 25 cm by the time the cotyledons unfold and may reach a depth of 3 m by mid-season. The plant remains unbranched for about 1 month. The shoot system is dimorphic, with the main axis and lower branches (emerging from axillary buds) being monopodial and vegetative, whereas the fruiting branches (emerging from extra-axillary buds) are sympodial. Fruiting branches develop as primary branches higher on the main stem and as secondary branches on vegetative branches. Generally only one fruiting branch develops at each node, with 3–5 fruits per branch. In *Gossypium hirsutum* the first fruiting branch appears at node 4–5 of the main stem, between 1 and 2 months after sowing, and 35–70 days after sowing the first visible flower buds appear as small, green, pyramidal structures, known as 'squares'. They need 20–35 days to develop into open flowers. The flowers mostly open near dawn and pollination normally occurs within a few hours. Self-pollination is the predominant mating system, but visiting insects can cause considerable outcrossing (up to 40%). The flowers turn pink in the afternoon and red by the following day. They start withering late on the second day and die on the third day. Flowering peaks at 3(–6) weeks after the onset and may continue for about 6 weeks. The fruits grow very quickly after pollination, reaching their final size in 15–25 days. After a further (20–)25–45(–60) days, depending on genotype and environmental conditions, they are ripe. Usually the dry fruits open at their sutures and the white, fluffy fibre-mass emerges. The seeds remain attached to the placenta and are only separated by picking or by very strong rain or wind.

During the first 2–4 weeks after flowering (the elongation phase) the fibres grow rapidly, reaching their full length, and during the next 4–6 weeks (the secondary thickening phase) the cell walls of the fibres thicken through deposition of cellulose in consecutive layers. The cell wall thickness of a fibre, or the degree to which the fibre has been filled with cellulose, mainly depends on plant vigour during ripening. Upon boll opening the fibre dries and the lumen collapses, resulting in the characteristic twisted, ribbon-like appearance of the fibre that makes it spinnable.

Shedding of squares and young bolls is common in cotton. It is aggravated by adverse conditions such as prolonged overcast weather, extreme temperatures, water stress, waterlogging, nutrient deficiencies, diseases and insect damage. Commonly 60% of the squares and young bolls are shed, but flowers are rarely shed. The ability to overcome adverse events by compensatory growth is characteristic for cotton. However, recovery is only partial and insignificant when severe insect damage occurs late in the season.

Ecology *Gossypium hirsutum* requires a temperature of (15–)22–36(–42)°C during the growing season. The optimum temperature for germination is 29–30°C and the minimum temperature for germination of most cultivars is about 14–15°C, though some germinate at temperatures as low as 12°C. For optimum growth and development an average growing season temperature of 25–30°C is needed. Cool weather slows growth and development, leading to retarded and sometimes insufficient ripening. Cotton is extremely frost-sensitive. Ample sunshine promotes flowering and fruit set and the highest yields are obtained in dry areas under irrigation, for example in Arizona, United States. Cotton does not tolerate shade. The rainfall during the growing season should be (450–)750–1200(–1500) mm, with dry weather during ripening, because rainfall after fruit opening leads to a decreased fibre quality. Because of its deep rooting system, cotton is drought tolerant, but prolonged drought during flowering and fruiting causes yield reduction. Strong winds can damage the seedlings and the open bolls. Primitive cottons are usually photoperiod-sensitive, becoming reproductive at short to medium photoperiods, but modern cultivars are generally photoperiod-insensitive and can be grown at a wide range of latitudes. In tropical Africa *Gossypium hirsutum* is grown from sea-level up to 2000 m altitude.

Gossypium hirsutum can be grown on medium to deep, light to heavy, well-drained soils with a moderate fertility and a pH of (5–)6–7.5(–9.5). Very fertile soils stimulate vegetative growth and may cause an excessively long vegetative period. Cotton is relatively salt tolerant, with a salt content of 0.5–0.6% normally not causing damage, but cultivars differ considerably in this respect.

Propagation and planting Cotton is propagated by seed. Seed saved from the previous harvest is rarely used, as the entire harvest is usually sold for ginning. Organized seed multiplication and distribution is important to guarantee seed quality and purity. It is usually recommended that seed be delinted by mechanical or chemical means, with the former being preferred for economic and environmental reasons. For mechanical sowing, removal of the fuzz is essential. Seeds lose their viability rapidly if their moisture content exceeds 10%, but seeds with a moisture content of 7% can be stored in sealed jars for up to 15 years. The 1000-seed weight of non-delinted seed is 50–150 g.

Cotton is sown directly in the field, and in tropical Africa this is generally done by hand. The sowing date is chosen in such a way that the harvest will coincide with the beginning of the dry season. The planting density varies widely with cultivar, climate and soil characteristics, and cultivation as well as harvest methods.

Spacings are 50–120 cm between rows and 15–60 cm within the row. It is advised not to sow less than 5 seeds per hill. About 20–25 kg/ha delinted seed is necessary for sowing, for instance at 80 cm × 30 cm spacing (41,700 hills/ha) with 5 seeds per hill. The seed should not be sown deeper than 4–5 cm in sandy soils and 2–3 cm in clay soils. Fuzzy seeds require more water for germination compared to delinted seeds because imbibition of water is faster in delinted seeds.

Good soil preparation before sowing is very important, because the seedlings do not penetrate hard or crusted soils easily and do not compete well with weeds until they are 3 weeks old. Dry season weeds can be killed by harrowing or hoeing. This greatly reduces weed competition after planting. Early soil cultivation, allowing early planting, extends the growing season. Although hand hoeing is predominant in some parts of Africa, animal- and tractor-drawn ploughs are being used more and more. Most cotton in Africa is grown on the flat, but ridges are necessary on poorly drained soils.

It is possible to propagate cotton vegetatively by cuttings, budding or grafting. The development of rapid, reproducible and genotype-independent systems of in-vitro propagation of *Gossypium* species has been difficult, though methods have now been developed to produce large numbers of somatic embryos from callus from hypocotyl or cotyledon explants of *Gossypium arboreum*, *Gossypium barbadense*, *Gossypium herbaceum* and *Gossypium hirsutum*.

Cotton is usually grown in rotation with other crops to control pests and soil-borne diseases. In northern Côte d'Ivoire, for instance, it is grown in a 4-year rotation, with cotton in the 1st year, maize in the 2nd, groundnut in the 3rd and sweet potato and/or cassava in the 4th. After these four years, the field is returned to fallow. Cotton may be intercropped with other annual crops, such as maize, sorghum and grain legumes.

Management Within 2 weeks after sowing, gaps in the stand of cotton are resown, the crop is thinned and a first weeding round takes place. A second weeding and the final thinning and ridging are carried out 4–5 weeks after sowing, and the final weeding another 2–3 weeks later. In tropical Africa weeding is usually done by hand, but in West Africa draught animals are often used for between-row weeding and ridging. Herbicides are sometimes applied.

Cotton has a very good nutrient uptake ability, and nutrient requirements are therefore moderate. The uptake of a crop producing 1680 kg/ha seed cotton has been estimated at 105 kg N, 18 kg P and 66 kg K per ha. With the seed cotton 40 kg N, 7 kg P and 14 kg K per ha are removed; with the crop residues (especially the leaves) 65 kg N, 11 kg P and 52 kg K per ha are removed. Half the N and all P and K are usually applied around sowing. The 2nd application of N is given about a month after sowing, at final thinning. Too much N stimulates vegetative growth and extends the vegetative period, whereas N-shortage leads to chlorosis, reduced growth and boll-shedding. Sufficient K is important for fibre quality and disease resistance and shortage leads to mottled yellowish leaves with brown concentric spots, with the leaf margins drying and curling inwards, and the leaves eventually drying out and being shed. P-deficiency results in dark green leaves and delayed flowering and fruiting.

Gossypium hirsutum is mostly grown under rainfed conditions. Under rainfed conditions supplemental irrigation may help early planting and alleviate dry spells in mid season. To stop vegetative development, irrigation should cease shortly after boll opening has started.

Cotton can be grown as a perennial and be cut back and ratooned, but this is not advisable, because perennial cotton can act as a host reservoir for cotton pests and diseases.

Diseases and pests Diseases are less important in cotton than pests. The most widespread diseases are bacterial blight, leaf spot, blackarm or boll rot caused by *Xanthomonas axonopodis* pv. *malvacearum* (synonym: *Xanthomonas campestris* pv. *malvacearum*), anthracnose caused by *Glomerella gossypii* (anamorph: *Colletotrichum gossypii*), Fusarium wilt caused by *Fusarium oxysporum*, and Verticillium wilt caused by *Verticillium dahliae*. Bacterial blight is controlled by growing cotton only once every 3 or more years on the same field, removing the harvest remains and seed treatment. *Gossypium hirsutum* cultivars with adequate host resistance are available. Anthracnose can be controlled by the same measures, but resistant cultivars are not available. *Gossypium hirsutum* cultivars with resistance to Fusarium wilt are available. Cropping methods to control wilt diseases include crop rotation, sufficient K-fertilization and the control of nematodes. The most important virus diseases of cotton in tropical Africa are leaf curl, African cotton mosaic and cotton blue disease. Virus diseases are controlled by eliminating reservoir hosts and vectors, and by using tolerant or resistant cultivars.

Cotton suffers from a wide spectrum of pests. Bollworms are among the most serious pests. They feed inside the bolls, damaging lint and seed and so causing considerable reduction in yield and quality. The main bollworms are American bollworm (*Helicoverpa armigera*), pink bollworm (*Pectinophora gossypiella*) and spiny bollworm (*Earias* spp.). Spiny bollworm, to which *Gossypium hirsutum* seems more susceptible than *Gossypium arboreum* and *Gossypium barbadense*, has a serious early effect of tipboring in the main stem leading to excessive formation of vegetative branches and delaying the setting of bolls, which makes them vulnerable to mid-season American bollworm and stainers. Control of bollworms has long relied heavily on insecticides. More recent is the use of genetically modified cultivars which are resistant.

Leaf, stem and bud-sucking bugs can cause considerable damage. Jassids (*Amrasca*, *Empoasca*, *Erythroneura*, *Jacobiella* and *Jacobisca* spp.) are the first pests to appear, but a dense coating of long hairs on leaves and stems provides good protection. Whitefly (*Bemisia tabaci*) and cotton aphid (*Aphis gossypii*) are pests later in the season; the former is the vector of leaf curl and African cotton mosaic, the latter of cotton blue disease. Early sowing, weeding and harvesting and the use of short-season cultivars can reduce their damage. Cotton stainers (*Dysdercus* spp.) occur in all cotton-growing countries. They pierce the green bolls and inject the fungus *Nematospora gossypii*, which causes yellow staining of the lint, resulting in lower quality. About 4 alternating sprays of organophosphates and pyrethroids can overcome this pest. Fairly effective preventive control can be obtained by strict phytosanitation, early cropping of maize or sorghum followed by early ploughing and close planting of cotton using an early-maturing cultivar. The boll weevil (*Anthonomus grandis*) is economically the most serious cotton pest in the United States. Close relatives of cotton, such as *Abutilon* and *Hibiscus* species growing nearby are alternative hosts of cotton pests, especially stainers.

Insect pests in cotton have been effectively controlled since 1945 with the use of insecticides. In tropical Africa control programmes are usually based on 4–6 sprayings per year, with the first one at 45–60 days after sowing, and subsequent sprayings every 2 weeks. The first 2–4 sprayings are usually with a pyrethroid and an organophosphorus compound, the other ones only with a pyrethroid. The repeated development of resistance of insect pests (especially the American bollworm) to new insecticides has in some countries led to excessive spraying, killing all natural enemies. This may also induce outbreaks of previously minor pests, requiring additional spraying. To reduce the use of pesticides, the application of Integrated Pest Management (IPM) or Integrated Weed and Pest Management (IWPM) is advocated. Very early field preparation including repeated weeding, fertilizer application, early planting of jassid-resistant cultivars, gapping, thinning and judicious use of pesticides on the basis of insect monitoring and damage thresholds, form the basis of interacting IWPM farming practices. Preventive weed control by ploughing or hoeing promptly after clearing the preceding crop stores moisture from unexpected storms in the subsoil which makes it possible to plant early. This encourages early fruiting well ahead of the main pest, American bollworm, and provides ample time for compensatory fruiting in case of early fruit damage. As insecticides against jassids are no longer needed they do not kill the natural enemies which control American bollworm in its vulnerable young stage. By the time the later pink bollworms, stainers and whitefly occur, the main crop will be safe.

The most widely distributed economically important nematode in cotton is the root-knot nematode (*Meloidogyne* spp.), whereas the reniform nematode (*Rotylenchus* spp.) is more restricted to tropical and subtropical environments. They can be controlled by rotation and chemicals, whereas cotton genotypes have been developed with some tolerance to the reniform nematode.

Harvesting In tropical Africa cotton harvesting is generally done by hand, usually in 3 rounds, because leaving open bolls in the field may result in deterioration of lint quality. The first picking starts about 10 days after the fruits have opened, the other rounds follow at intervals of a little over 1 week. The cotton should be sorted right away during harvesting into white cotton, stained cotton and waste. At harvesting, the cotton must be as dry as possible. In forest regions and in the event of late rains, additional drying on racks may be necessary. Hand-picking gives cleaner cotton and a higher recovery than mechanical harvesting.

Mechanical harvesting is practised in the

United States and Australia, where hand-picking is too expensive; here low-growing, weakly-branching cultivars are sown at narrow spacings, and plants are sprayed with defoliants before harvesting. Mechanically harvested fibre needs heating and shaking to remove impurities, and this operation makes the fibre more brittle.

After picking, the seed cotton is cleaned and transported in bags or sheets to the ginnery for checking, weighing, sorting and payment. The seed from the first ⅓ of the crop picked is usually the most viable and may be kept separately in clearly marked bags. The lint from the first ⅔ of the crop is the most mature and strong.

After the cotton has been harvested, the cotton stems should be uprooted and burnt to prevent the build-up of pest and diseases.

Yield A seed cotton yield of up to 4 t/ha is possible under optimal conditions, but in practice it is seldom over 2.5 t/ha and the average world yield is about 2 t/ha. In most tropical African countries the yield is around 1 t/ha. Seed cotton of primitive cultivars yields 20–25% fibre after ginning, whereas good cultivars of upland cotton have a 'ginning-outturn' of at least 35% and sometimes over 40%. On average, 1 t seed cotton of *Gossypium hirsutum* yields 350 kg fibre, 120 kg oil, 300 kg cake, 160 kg hulls and 60 kg fuzz.

Handling after harvest In most tropical African countries, the harvested cotton is marketed through national agencies, but in some countries (for instance Nigeria and Kenya) it is done in collaboration with the private sector. In the case of national structures, yield forecasts are made by extension workers, to enable the mobilization of sufficient transport and processing facilities. In most countries the harvested cotton is separated into clean seed cotton and stained or trashy seed cotton.

Cotton lint is removed from the seeds by ginning, which can be done with a hand gin (capacity of 2–3 kg lint/hour) or mechanically. Mechanical ginning can be done with a saw gin (capacity of 300 kg lint/hour) for the shorter stapled cottons, or with the more gentle roller gin (capacity of 30 kg lint/hour) for the longer stapled fine types. In some African countries, such as Kenya and Uganda, roller ginning is common, even for shorter stapled cotton. In West and Central Africa manual ginning may be done by placing the seed cotton on a block of wood or a flat stone, and squeezing out the seeds by rolling an iron or wooden rod over it. The optimum moisture content of the fibre for ginning is 5–7%. When the moisture content is lower, excessive fibre damage occurs; when it is higher, the amount of broken seeds is higher. The ginning outturn (the fibre weight as a percentage of the weight of the seed cotton) ranges from 44% in Côte d'Ivoire to 28–35% in DR Congo. After ginning, the fibres are pressed into bales of 216 kg and the seeds are transported to the oil mill.

Cotton fibre quality is defined in terms of its length and uniformity, strength, elasticity and maturity, whereas whiteness and trash content also play a role. These properties can all be measured rapidly by the 'High Volume Instrument' (HVI).

At the oil mill, fuzz is removed by additional saw ginning before seeds are crushed. The oil is usually extracted mechanically in a screw press, or chemically with a solvent. For local use in Nigeria the oil is obtained by grinding the seeds in hot water.

For papermaking, linters are pulped by caustic solutions and bleached. Cotton textile cuttings and rags are pulped using the soda process. Dyed textiles and the presence of synthetic fibres and elastic materials in rags can cause problems in paper making.

Genetic resources In Uzbekistan the Cotton Breeding Institute, the Institute of Genetics and Plant Experimental Biology and the National University of Uzbekistan together hold about 13,200 *Gossypium hirsutum* accessions. The cotton collection of the Chinese Academy of Agricultural Sciences (CAAS) kept in Beijing, Anyang and Hainan Island, contains about 7700 *Gossypium hirsutum* accessions. In India about 7600 *Gossypium hirsutum* accessions are kept at the Central Institute for Cotton Research (CICR) in Nagpur and Coimbatore, and the National Bureau for Plant Genetic Resources (NBPGR) in New Delhi. The Cotton Germplasm Collection of the United States Department of Agriculture, Agricultural Research Service (USDA/ARS) at College Station in Texas, United States, contains about 6300 accessions of *Gossypium hirsutum*). In Russia the N.I.Vavilov Institute of Plant Industry (VIR) in St Petersburg holds about 4500 accessions of *Gossypium hirsutum*. The genebank of the Centre de Coopération Internationale en Recherche Agronomique pour le Développement (CIRAD) at Montpellier, France, also contains about 2200 accessions of *Gossypium hirsutum*. The Brazilian Agricultural Research Corporation (EMBRAPA) maintains about 1700 *Gossypium hirsutum* accessions. In Australia about 1500 accessions of *Gossypium hirsutum* are held by the Commonwealth Scientific and Industrial Research Organisation (CSIRO) in Narrabri, and the Australian Tropical Grains Germplasm Centre (ATGGC) in Biloela.

Breeding Until the 1930s cotton breeding was limited to crossing within the diploid and tetraploid groups. After this, polyploidization of the diploids greatly increased breeding opportunities. Crosses between Old World and New World genotypes have become important, especially for resistance breeding and the breeding of better cultivars for regions in Asia where *Gossypium arboreum* and *Gossypium herbaceum* grow well, but *Gossypium hirsutum* does not. F1 hybrid cultivars with considerable hybrid vigour for yield have been successfully developed. However, the available systems of cytoplasmic male sterility have been inadequate for large-scale production of hybrid seed, mainly due to incomplete expression of fertility restorer genes in the male parents. Current use of cotton hybrids is limited to South Asia and China, where seed production by manual emasculation and pollination is economically feasible because of low labour costs.

The main objectives in cotton breeding, apart from higher yields, are photoperiod-insensitivity, early maturity, adaptation to mechanical harvesting (through low growth, little branching, short flowering period, loosely attached seeds, less hairy leaves), fibre quality (length, fineness, strength and elasticity), seed quality (high oil content and low gossypol content, increased suitability of the presscake as a source of protein for humans and animals), resistance to diseases (e.g. bacterial blight and Fusarium wilt) and pests (e.g. bollworms, jassids) and tolerance to drought, cold and salinity. There has been little progress in breeding for pest resistance (except for resistance to jassids), but much success has been obtained in resistance and tolerance to Fusarium and Verticillium wilts, bacterial blight and nematodes.

Cotton breeding is based on the great variability in plant characteristics (plant structure, leaf shape, fruit size and fibre characteristics such as length, quality and colour) within populations of cultivated cotton resulting from spontaneous hybridization and mutations that have occurred over many years. Two methods successfully applied in cotton breeding include mass or line selection, used to select new strains from varieties that are already adapted for cultivation, and genetic crossing, used to combine favourable characteristics of related parents. Cotton breeding is based on two important criteria: fibre properties (length, uniformity, fineness, maturity, strength, colour), and productivity (plant habit, earliness or lateness, boll shedding, boll size, manner of boll opening, hairiness, bract characteristics).

Cotton breeding work in Africa is build on earlier breeding in the United States. The work on *Gossypium hirsutum* race 'latifolium' was centred on fruiting irrespective of daylength, and photoperiod neutral cultivars developed in the United States have been introduced successfully into almost all cotton growing areas of the world. Most cotton-growing countries in sub-Sahara Africa have their own breeding programmes. Very successful breeding programmes were undertaken by the Cotton Research Cooperation (CRC) in East Africa, and the Research Institute for Cotton and Exotic Textiles (IRCT) in West Africa. The main thrust of the breeding work was development of high-yielding cultivars and the incorporation of resistance to pests and diseases. The breeding work helped to raise average lint yields of rainfed cotton from 200 to 1000 kg/ha, and the ginning outturn from 35 to 42%. Furthermore, the ALBAR gene for resistance against bacterial blight, and hairy leaf surface for resistance to jassids and aphids were incorporated. Thus, some of the best cottons in the world have been produced from the medium long staple upland cottons bred in East Africa and grown in the Mwanza region in Tanzania and the cotton growing areas of Uganda. Current breeding work in tropical Africa is focused on developing early maturing and drought tolerant cultivars for regions with low and erratic rainfall, and high-yielding cultivars for production under irrigation.

Molecular breeding has been applied to cotton with considerable success. Genetically modified (GM) *Gossypium hirsutum* cultivars were worldwide grown on 21 million ha in 2010. An important example is Bt-cotton, GM cotton with resistance to bollworms based on Bt genes derived from *Bacillus thuringiensis*. The first commercial release of Bt-cotton in sub-Saharan Africa was in 1999 in South Africa, where Bt-cotton was reported to give higher yields and to reduce the use of pesticides. However, the economic advantages for farmers were less than originally expected, because of the continued need for spraying against other pests and the high price of the Bt-cotton seed. In Burkina

Faso field trials with Bt cotton were started in 2003/2004, and it was found that bollworm incidence was reduced by 92%, while yields increased by 15–20%. About 115,000 ha were sown with Bt-cotton in Burkina Faso in 2009, and 260,000 ha, by 80,000 farmers, in 2010. In Tanzania field trials with Bt-cotton were started in 2005. Cotton has also been genetically modified to express resistance to the herbicides bromoxynil ('bromoxynil-resistant cotton') and glyphosate ('glyphosate-tolerant cotton'). Some GM cotton cultivars have combined insect and herbicide resistance. So far, there has been little proven evidence of negative effects of GM cotton on the environment.

Prospects Although the share of cotton fibre in the world fibre market (including synthetic fibres) has decreased from 50% in the 1970s to 36% in 2008, the demand for cotton fibre has grown consistently. Long-term projections suggest that world consumption of textile fibres will expand annually by about 3.3% in the next decade to 110 million t in 2020. Thus, the demand for cotton fibre is expected to rise significantly. In the past decades the cotton production in tropical Africa increased, especially in West Africa, where the growth rate was much higher than world average. Thus, with proper strategies and technologies in place, tropical Africa can make a significant contribution to meeting increased cotton demands of the world market in the future. *Gossypium hirsutum* will remain the most important source of cotton, as it is highly productive and shows strong yield responses to improved growing conditions, fertilizers, crop protection and supplementary irrigation.

An important issue in cotton cultivation is the high level of pesticide use. To lower the use of pesticides, Integrated Pest Management should be further developed in close cooperation with cotton farmers. The use of genetically-modified cotton such as Bt-cotton and herbicide-resistant cotton is another promising option, though its use is still meeting public resistance in some countries. Concerns about the negative effects of common cotton growing practices, especially the large amounts of pesticides applied, on human health and the environment has led to increased importance of organic cultivation. However, yields are low in organic cotton growing, and, consequently, the price is very high.

Major references Burkill, 1997; Eicher, Maredia & Sithole-Niang, 2006; FAO, 2011; Fryxell, 1978; Kerkhoven & Mutsaers, 2003; Matthews & Tunstall, 2006; Neuwinger, 2000; Peeters et al., 2001; Smith & Cothren (Editors), 1999; Verdcourt & Mwachala, 2009.

Other references Adjanohoun et al., 1989; Anonymous, 2008; Bhat, Etejere & Oladipo, 1990; Campbell et al., 2010; David & Falegan, 2007; Dowd, 2011; ECOCROP, 2007d; ICAC, 2008; ISAAA, 2011; Jarman, 1998; Lopes & Steidle Neto, 2011; Lukonge, Labuschange & Hugo, 2007; Mellet, Schoeman & Broodryk, 2003; Morse, Bennett & Ismael, 2005; Patel et al., 2002; Purseglove, 1968; Seignobos & Schwendiman, 1991; Smith, 1995; Ververis et al., 2004; Wallace et al., 2009.

Sources of illustration Kerkhoven & Mutsaers, 2003.

Authors E.C. Ikitoo

Based on PROSEA 17: Fibre plants.

GREWIA GLANDULOSA Vahl

Protologue Symb. bot. 1: 34 (1790).

Family Tiliaceae (APG: Malvaceae)

Synonyms *Grewia ulmifolia* Bojer (1846).

Vernacular names Dune cross-berry (En). Msokote, msai (Sw).

Origin and geographic distribution *Grewia glandulosa* is distributed along the coasts of Kenya, Tanzania and Mozambique, and also occurs in the Indian Ocean islands (Comoros, Mayotte, Madagascar and Seychelles). It has probably been planted in Mauritius.

Uses The bark fibre is used in Madagascar to make good cordage. It was used for tying wood before nails were used. On Zanzibar and Pemba young branches have been used to clean the teeth. In East African traditional medicine a decoction of the root is drunk against flatulence. In Madagascar it is recommended to drink an infusion of the flowering shoot before going to sleep, because of its emollient and calming effects.

Botany Shrub or small tree up to 7.5 m tall; young stems shortly stellate-hairy. Leaves alternate, simple; stipules subulate, 5–10 mm long, finely hairy; petiole 6–12 mm long, stellate-hairy; blade ovate to elliptical-oblong, 4.5–15 cm × 2.5–8.5 cm, base rounded, cordate or truncate, apex acute to acuminate, margin finely and evenly toothed and somewhat glandular, more or less glabrous above, scattered stellate-hairy below. Inflorescence a terminal or leaf-opposed axillary cyme, 2–5-flowered; peduncle up to 9 mm long, hairy; bracts up to 7 mm long. Flowers bisexual, regular, 5-merous;

pedicel thick, up to 11 mm long; sepals linear-oblong, 10–25 mm long, hairy outside, glabrous inside; petals obovate to almost circular, 5–12 mm × 5–6 mm, pinkish purple, with a narrow nectariferous claw c. 1 mm long; androgynophore glabrous for 1.5–2 mm at the base, hairy above the node; stamens numerous, 10–14 mm long, filaments pink to mauve; ovary superior, c. 2.5 mm long, densely hairy, style 5–10 mm long. Fruit a more or less square drupe, 14–28 mm wide, 10–16 mm high, shallowly 4-lobed, densely covered with rusty brown stellate-hairs.

In Kenya *Grewia glandulosa* flowers more or less throughout the year.

Grewia comprises about 150 species, distributed in the tropical and subtropical parts of Africa, Asia and Australia. Other *Grewia* species of which the bark has been used for making bark cloth, cordage and textiles in Madagascar include *Grewia brideliifolia* Baill. (synonym: *Grewia faucherei* Danguy), *Grewia calvata* Baker, *Grewia cuneifolia* Juss. (synonym: *Grewia trinervata* Baker), *Grewia microcyclea* (Burret) Capuron & Mabb., *Grewia speciosa* Burret (synonym: *Grewia macrophylla* Baker), *Grewia rhomboides* Bojer (synonym: *Grewia polypyrena* Baker), *Grewia sahafariensis* Capuron & Mabb. and *Grewia sely* R.Vig. The bark of *Grewia calvata* was formerly beaten with a mallet to obtain barkcloth. As technology evolved, fibres were extracted by crushing the bark, after which they were combed or scutched, making them suitable for spinning and weaving. The fibre of *Grewia calvata* is much appreciated and can be as finely woven as hemp fibre. The young, straight stem of *Grewia calvata* is often made into canes and walking sticks. The wood of *Grewia microcyclea* provides poles used as barge poles for pirogues, and is also used for spear shafts, tool handles and roofing; the fruit is edible. The wood of *Grewia sahafariensis* and *Grewia sely* is made into spear shafts. The seed of *Grewia rhomboides* is edible and has been harvested as a famine food.

Ecology In East Africa *Grewia glandulosa* is common in coastal areas, in dry forest and bush on coral rag and cliff tops, from sea-level up to 50 m altitude, often forming thickets just above the high-water mark. In Madagascar it occurs up to 1000 m altitude.

Genetic resources and breeding In view of its fairly wide distribution and common occurrence, *Grewia glandulosa* seems not threatened by genetic erosion.

Prospects *Grewia glandulosa* is a relatively unimportant local source of fibre and medicine in coastal areas of East Africa and the Indian Ocean islands. Its importance is unlikely to increase.

Major references Boiteau, Boiteau & Allorge-Boiteau, 1999; Decary, 1946; Mabberley & Capuron, 1999; Schatz, undated; Whitehouse et al., 2001.

Other references Beentje, 1994b; Bosser, 1987; Green, 1925; Kokwaro, 1993; Rolland & Boullet, 2005; Stiles, 1998; Wild, 1963; Wild & Gonçalves, 1969.

Authors M. Brink

GREWIA LASIODISCUS K.Schum.

Protologue Notizbl. Bot. Gart. Berlin-Dahlem 3: 100 (1901).

Family Tiliaceae (APG: Malvaceae)

Origin and geographic distribution *Grewia lasiodiscus* is distributed in the West African savanna zone from Senegal to northern Nigeria.

Uses Fibre from the bark is made into cordage. In Senegal the bark is used to cover groundnut baskets. The stem is used for wickerwork, baskets and fish traps, and twigs are used as toothbrushes. The bark is used to precipitate impurities in traditional beer making. The fruit is edible and is sometimes made into a fermented beverage. It is also used as a condiment.

In African traditional medicine a maceration of the root is drunk to treat intercostal pain, female sterility and urinary retention. It is also drunk or used in baths to treat diarrhoea and as a mild aphrodisiac. A paste of the freshly ground root is applied as a poultice on the chest and drunk for treatment of intercostal pain and stiffness of the limbs. The root is also used to control fever, pain and vomiting. The branch and the pounded bark are cooked with food to prepare a sauce eaten against stomach problems. A maceration of the bark fibre is drunk for treatment of diarrhoea and constipation. A maceration of the leaf is drunk to treat urinary retention.

Properties The root contains saponins, tannins and terpenes. An aqueous methanol extract of the root has shown in-vivo anti-emetic activity in 1-day-old chicks. The bark and flowers contain farnesol, which has shown spasmolytic effects on the smooth muscle fibre of intestines and sedative activity in case of overexcitement.

Botany Shrub or small tree up to 6 m tall; branches cylindrical, often entangled, grey-brown, with lenticels, glabrescent; outer bark smooth or fissured and scaly, brown or grey, inner bark orange-pink, sometimes with purple streaks. Leaves alternate, simple; stipules forked, 2–6 mm long; petiole 2–4 mm long, hairy; blade ovate, elliptical or oblong, 2.5–10 cm × 1.5–5.5 cm, base rounded to almost cordate, apex obtuse to pointed, margin toothed, 3-veined from the base, with 4–8 pairs of secondary veins, slightly leathery, stellate-hairy on both sides. Inflorescence an axillary fascicle, 1–4-flowered; peduncle 3–4 mm long. Flowers bisexual, regular, 5-merous, c. 2 cm in diameter; pedicel 4–7 mm long; sepals 8–12 mm long; petals linear, smaller than sepals, bright yellow to reddish brown; stamens numerous; ovary superior. Fruit a globose drupe 7–12 mm in diameter, unlobed, brown, hairy, rough, 1–2-seeded. Seedling with epigeal germination.

Grewia lasiodiscus usually flowers at the beginning of the rainy season. In Benin flowering is in April–June, and fruiting in August–December.

Grewia comprises about 150 species, distributed in the tropical and subtropical parts of Africa, Asia and Australia.

Ecology *Grewia lasiodiscus* occurs in the Sudano-Guinean zone of West Africa, in savanna, fallow land and gallery forest. It occurs scattered and usually not frequently, but it may be locally common.

Management Soaking in sulphuric acid for 60 minutes, followed by soaking in water for 24 hours gave the best results in germination experiments in Burkina Faso, with germination rates of about 40%.

Genetic resources and breeding In view of its fairly wide distribution, *Grewia lasiodiscus* seems not threatened by genetic erosion.

Prospects *Grewia lasiodiscus* is a local source of fibre and material for wickerwork, and also provides other useful products, such as edible fruits and traditional medicines. Information on the fibre properties is lacking, making it difficult to assess the prospects for this species. It may gain importance as a medicinal plant, because of its anti-emetic properties.

Major references Arbonnier, 2000; Burkill, 2000; Keay, 1958h; Van den Eynden, Van Damme & de Wolf, 1994.

Other references Adjanohoun et al., 1989; Akoègninou, van der Burg & van der Maesen, 2006; Bazié, 2007; Neuwinger, 2000; Tijani et al., 2008.

Authors M. Brink

GREWIA TRICHOCARPA Hochst. ex A.Rich.

Protologue Tent. Fl. Abyss. 1: 89 (1847).

Family Tiliaceae (APG: Malvaceae)

Synonyms *Grewia mollis* var. *trichocarpa* (Hochst. ex A.Rich.) Burret (1910).

Vernacular names Mkole (Sw).

Origin and geographic distribution *Grewia trichocarpa* is distributed in DR Congo, Rwanda, Burundi, Sudan, Eritrea, Ethiopia, Somalia, Kenya, Uganda and Tanzania. It also occurs in Saudi Arabia and Yemen.

Uses The bark fibre is used for tying, e.g. in hut construction and in basketry. The pounded bark is used for soap-making. The woody branches and wood are used for withies, construction, floors of granaries, tool handles, walking sticks, bows and spear- and arrow-shafts. It is also used as fuelwood. The aerial parts are browsed by livestock and game. The flowers are a source of bee forage. The ripe fruit is eaten.

In African traditional medicine a root decoction is drunk to expel worms and against diarrhoea. A watery extract of the root and that of *Grewia tenax* (Forssk.) Fiori, is rubbed in to treat skin tuberculosis and other skin ailments. The leaf sap is drunk to treat coughs, colds, abscesses and anaemia. A decoction of the leaf is drunk to expel the placenta, and used as an enema against intestinal parasites. A leaf dressing is applied against furuncles.

Botany Evergreen shrub or small tree up to 6 m tall; crown spreading; branches cylindrical, purplish with pale lenticels, glabrous to hairy in young parts; outer bark smooth, silver-grey to brown, sometimes with vertical bands of brown lenticels. Leaves alternate, simple; stipules subulate, 6–8 mm long; petiole 2–8 mm long, pubescent; blade ovate to elliptical, 1–12(–17) cm × 1–5(–7) cm, base obliquely truncate to rounded, sometimes slightly asymmetric, apex acute to acuminate, margin toothed, 3-veined from the base, glabrous or scattered to sparsely minutely stellate-pubescent above, indumentum beneath variable. Inflorescence a cyme, 1–3 together in a leaf axil, 4–30 mm long, (1–)2–3-flowered; peduncle 4–12 mm long. Flowers bisexual, regular, 5-merous; pedicel 3–12 mm long; sepals elliptical, 6–11 mm long; petals oblong to ovate, 3–7 mm long, notched at the apex, yellow; androgynophore up to 1.5 mm long, glabrous, apex densely hairy; stamens numerous, 4–6 mm long, yellow to orange; ovary superior, 1–2 mm long, densely hairy, style 4–5 mm long, stigma 4-branched. Fruit an unlobed (sometimes 2-lobed) drupe 4–7 mm × 4–7 mm, glabrous or sparsely hairy, yellow to orange; endocarp hard, woody, reticulate.

In Kenya *Grewia trichocarpa* flowers throughout the year. The ripe fruits are collected in April–June in Tanzania.

Grewia comprises about 150 species, distributed in the tropical and subtropical parts of Africa, Asia and Australia. The bark of *Grewia microcarpa* K.Schum., a shrub or small tree up to 9 m tall distributed in Kenya, Tanzania, Malawi, Zimbabwe and Mozambique, is locally used as string. In Angola fibre from the bark of *Grewia cyclopetala* Wawra, a shrub or tree up to 8 m tall, is used for making baskets.

Ecology *Grewia trichocarpa* occurs at (600–)900–2150(–2400) m altitude, on sandy or rocky soils, in wooded grassland, bushland, dry forest and riverine forest. In Tanzania it is common, occurring in areas with an average annual rainfall of 900–1400 mm.

Management *Grewia trichocarpa* can be propagated by seed. In Tanzania it is neither planted nor protected by local people. In Uganda it is sometimes considered a weed in plantation forestry.

Genetic resources and breeding In view of its fairly wide distribution, *Grewia trichocarpa* seems not threatened by genetic erosion.

Prospects Like other *Grewia* spp., *Grewia trichocarpa* is a useful multipurpose plant, providing not only fibre, but being a local source of wood, fuel, forage, edible fruits and traditional medicines. Unfortunately, information on properties, such as fibre, wood and fodder quality and medicinal properties, is lacking, making it difficult to assess the prospects for this species.

Major references Beentje, 1994b; Neuwinger, 2000; Ruffo, Birnie & Tengnäs, 2002; SEPASAL, 2009d; Whitehouse et al., 2001.

Other references Brokensha & Riley, 1986; Geissler et al., 2002; Ichikawa, 1987; Leyens & Lobin, 2009; Lusigi, Nkurunziza & Masheti, 1984; Medley, 1993; Sebsebe Demissew, 1999; Vollesen & Demissew Sebsebe, 1995; Watt & Breyer-Brandwijk, 1962; Wilczek, 1963.

Authors M. Brink

GREWIA TRIFLORA (Bojer) Walp.

Protologue Repert. Bot. Syst. 5: 119 (1845).

Family Tiliaceae (APG: Malvaceae)

Synonyms *Grewia vaughanii* Exell (1928).

Vernacular names Masokote (Sw).

Origin and geographic distribution *Grewia triflora* is distributed in Kenya, Tanzania, Mozambique, the Comoros and Madagascar.

Uses The stem is used in Kenya for making fish traps. The bark has been used in Madagascar to make cordage. The wood is used in Kenya for construction poles, bows and shafts for spear-guns used for fishing. The fruit is edible. In traditional medicine in Madagascar the bark is used for treatment of headache, fever and diarrhoea, and the leaves to treat headache and epilepsy. A decoction of the aerial parts is drunk to treat fever.

Properties The wood is lightweight.

Botany Shrub or small tree up to 10 m tall. Leaves alternate, simple; stipules subulate, c. 4 mm long, glabrous; petiole 4–16 mm long, glabrous or with short stellate hairs; blade ovate, 3–11 cm × 2–6.5 cm, base rounded, truncate or slightly cordate, apex acute to acuminate, margin shallowly toothed to entire, 3-veined from the base, more or less glabrous, glossy green above, paler beneath, sometimes slightly glandular and sticky when young. Inflorescence a cyme, 1–2 together in a leaf axil, 1–3-flowered; peduncle 6–15 mm long; bracts united into an up to 4 mm long calyptra. Flowers bisexual, regular, 5-merous; pedicel 3–7 mm long; sepals 8–14 mm long, densely hairy outside; petals 4–8 mm long, bifid, yellow; androgynophore 0.5–1 mm long, glabrous; stamens numerous, 6–7 mm long, yellow; ovary superior, 1.5–2 mm long, densely hairy, style 5–8 mm long, stigma green. Fruit an unlobed, globose drupe 7–10 mm across, with short stellate hairs, dark brown.

In Kenya *Grewia triflora* flowers from November to June.

Grewia comprises about 150 species, distributed in the tropical and subtropical parts of Africa, Asia and Australia. *Grewia triflora* is closely related to *Grewia grevei* Baill. and *Grewia lavanalensis* Baill. (synonym: *Grewia repanda* Baker). Both are endemic to Madagascar, where they have been used for making cordage and barkcloth. The wood of *Grewia grevei* is used for poles, tool handles, bows of pirogues, and as fuelwood. It is easy to work and durable after impregnation with salt water. The fruit is edible, and the leaves are eaten by livestock.

The bark is used in traditional medicine to treat conjunctivitis, and the leaves to treat diarrhoea. The seed of *Grewia lavanalensis* is edible and has been harvested as famine food.

Ecology In East Africa *Grewia triflora* occurs in coastal forest and thicket, often on coral rag, from sea-level up to 50(–100) m altitude. In Madagascar, where it is very common, it is especially found in disturbed vegetation, such as in forest edges and openings.

Genetic resources and breeding In view of its fairly wide distribution and its common occurrence in Madagascar, *Grewia triflora* seems not threatened by genetic erosion.

Prospects *Grewia triflora* is a multipurpose plant, providing not only fibre for cordage, but also wood, edible fruits and traditional medicines. Information on properties, such as fibre and wood quality, is lacking, however, making it difficult to assess the prospects of this species.

Major references Beentje, 1994b; Capuron & Mabberley, 1999; Decary, 1946; Whitehouse et al., 2001; Wild & Gonçalves, 1969.

Other references Anderson, Cowlishaw & Rowcliffe, 2007; Boiteau, Boiteau & Allorge-Boiteau, 1999; Faurix et al., 1989; Kimani & Obura, 2004; Neuwinger, 2000; Ralantonirina, 1993; Ratsirarson & Ravaosolo, 1998; Razafiarison, 1993; Stiles, 1998; Weiss, 1973.

Authors M. Brink

HABROPETALUM DAWEI (Hutch. & Dalziel) Airy Shaw

Protologue Kew Bull. 1951: 336 (1952).

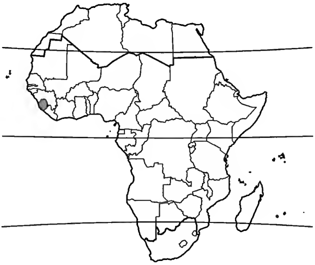
Family Dioncophyllaceae

Synonyms *Dioncophyllum dawei* Hutch. & Dalziel (1927).

Origin and geographic distribution *Habropetalum dawei* occurs in a 65–80 km long stretch along the coast in south-eastern Sierra Leone bordering Liberia. A recent single collection from Gabon needs confirmation.

Uses The stems serve as binding material and are used for tying house-posts. Split stems are considered good rope. Kwako people tie up their bundles of high quality piassava (*Raphia* spp.) with this material as a sort of trademark.

The leaves or the whole plant are used as a fish poison. The young pounded leaves mixed with palm oil are applied to the affected foot to kill jiggers. The plant is very floriferous and showy when in flower.



Habropetalum dawei – wild

Production and international trade *Habropetalum dawei* is only used locally.

Properties A phenol, present in the plant in a high concentration, has been found to kill fish at dilutions down to 10 ppm. Later, (+)-isoshinanolone isolated from an aqueous extract of the leaves was found to have fish-stunning activity. An acidified aqueous extract of the leaves yielded the benzofuran 2-methylbenzofuran-4-carboxaldehyde (habropetalal). It has strong bactericidal activity against *Staphylococcus albus* and *Escherichia coli* and fungicidal activity against *Mucor racemosus*.

Habropetalum dawei and other *Dioncophyllaceae* contain naphthyl-isoquinoline alkaloids with promising antimalarial and anti HIV properties. Habropetaline A (5'-O-methyldioncopeltine A) and 1,2,3,4-tetrahydro-1,3-dimethyl-8-isoquinolinol have been isolated from crude stem extract. Habropetaline A exhibits strong activity against *Plasmodium falciparum*, but is inactive against *Trypanosoma brucei rhodesiense*, *Trypanosoma cruzi* and *Leishmania donovani*. It also has some fish-stunning activity. The leaves also contain the related habropetaloic acid.

Botany A scandent or lianous soft-woody shrub attaining up to 10 m tall; branches terete, slightly striate, rusty velvety. Leaves alternate, simple; petiole c. 1 cm long, broad with narrow wings, not articulate; blade elongate-oblong, 12–45 cm × 2.5–5.5 cm, cuneate at the base, obtuse at the apex, thin-leathery, glabrous, veins from prominent midrib numerous, parallel, straight, thin, midrib extending into a prominent forked acumen with strongly recurved arms. Inflorescence a somewhat supraaxillary or terminal cyme, rusty velvety, densely flowered; peduncle c. 4 mm in diameter; bracts ovate-elliptical, up to 2 cm long, conspicuous. Flowers bisexual, actinomorphic, white; pedicel up to 4 mm in diameter; sepals 5, lanceolate-elliptical, 1–1.5 cm long, shortly connate at base; petals 5, free, spatulate-obovate, twice as large as sepals, white, very thin; stamens 10, unequal, filaments thin, anthers ellipsoid; ovary superior, obovoid, small, with 2 thread-like styles and head-shaped stigmas. Fruit a 2-valved capsule opening very early and well before maturity, with persistent calyx; valves small, c. 8 mm across at maturity; funicules 1–2 per valve, strongly elongated and thickened at maturity, up to 4 cm × 4 mm. Seed hanging from the open valves of the fruit, developing in the open, discoid, 4.5–9 cm in diameter, 2–3 cm thick, peltately attached to funicle, woody but light, with 1–2.5(–3) cm wide wing.

Flowers open in the early morning and fall before noon, or they open in the late afternoon and fall the next morning. They are visited by bees.

Dioncophyllaceae is a small family in the *Caryophyllales* s.l. comprising 3 genera in tropical West and Central Africa. *Habropetalum* is monotypic. *Caryophyllales* comprises, among others, several carnivorous families. In most *Dioncophyllaceae*, including *Habropetalum dawei*, this character is believed to be secondarily lost.

Ecology *Habropetalum dawei* occurs mostly in open, regularly flooded places in scrub, wooded or forested areas, usually on sandy coastal soil near the beach, in association with *Ochna multiflora* DC., *Hymenocardia lyrata* Tul. and *Hymenocardia heudelotii* Muell.Arg.

Management Seeds germinated in cultivation and plants have grown for a few years, but cultivation is very difficult. In the wild, the flowers are often damaged by a lepidopterous pest and fruits and seeds are rarely found.

Genetic resources and breeding *Habropetalum dawei* is believed to be a typical palaeoendemic with restricted distribution and reduced genetic plasticity, in the process of speciation. Although *Habropetalum dawei* is endemic to a small area, it is fairly common and not listed in the IUCN Red list of endangered species.

Prospects *Habropetalum dawei* will probably remain of only local use as a fibre plant. Recent information on its antimalaria and other medicinal properties is promising, but similar chemical compounds from related plants, especially *Ancistrocladus korupensis* D.W.Thomas & Gereau (*Ancistrocladaceae*) seem to have more direct pharmaceutical potential.

Major references Airy Shaw, 1951; Bringmann et al., 2003; Hanson, 1977; Hanson, Crawford & Thanasingh, 1981; Keay, 1954d.

Other references Bringmann et al., 1999a; Burkill, 1985; Gottwald & Parameswaran, 1968; Heubl, Bringmann & Meimberg, 2006; Hutchinson & Dalziel, 1928a; Kubitzki & Bayer, 2003; Meimberg et al., 2000; Metcalfe, 1951; Missouri Botanical Garden, undated; Neuwinger, 2004.

Authors L.P.A. Oyen

HALOPEGIA AZUREA (K.Schum.) K.Schum.

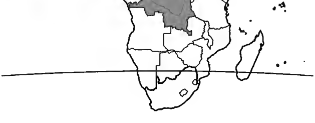
Protologue Engl., Pflanzenr. IV, 48: 50 (1902).

Family Marantaceae

Origin and geographic distribution *Halopegia azurea* is distributed from Sierra Leone to DR Congo and Cabinda (Angola).

Uses The leaves are widely used for thatching and food wrapping. In Nigeria they are also used as plates and for covering the bottom of baskets when carrying fruit. In Cameroon the leaves are used as cushion under sleeping mats, and to make a range of articles such as containers, plates, cups, pots, fans and parasols. The ash is sometimes used for making salt.

Production and international trade Bunches of leaves to be used for food wrapping were sold at prices ranging from US$ 0.04 to US$ 0.66 in markets of various towns in DR Congo



Halopegia azurea – wild

in 2006.

Properties Tests for the presence of alkaloids, flavonoids, saponins, quinones, tannins and terpenes gave negative results.

Botany Perennial herb with rhizome; stems short, bearing an inflorescence and a single subtending leaf, other leaves arising directly from the rhizome. Leaves imbricate, up to 1.5(–2) m long; petiole sheathing in the lower half, calloused just below the blade, up to 1 m long or more, apical calloused part 3–5 cm long, sheathed part hairy; blade linear-oblong, up to 50 cm × 15 cm, base attenuate to rounded, apex acuminate, upper surface dull green, lower surface whitish, sometimes reddish, veins parallel and numerous. Inflorescence spike-like, simple or bifurcate, shorter than leaves, up to 25 cm long; axes with internodes 15–20 mm long and nodes with distichous, abaxial bracts 25–50 mm long, each subtending 2 cymules; cymules 2-flowered, subtended by an adaxial bract; peduncle of cymule c. 3 mm long. Flowers bisexual, zygomorphic; 1 flower in each cymule sessile, the other with a winged pedicel 8 mm long, bracteole absent; sepals 2, unequal, 3 and 10 mm long respectively, white; corolla with a short tube at the base and 3 lobes, 20 mm long, blue; staminodes and stamen in 2 cycles, at the base forming a tube fused to the corolla tube, outer cycle consisting of petaloid, blue staminodes c. 25 mm long, inner cycle consisting of 2 smaller staminodes and 1 stamen; ovary inferior, silky, 3-locular. Fruit cylindrical, 11–12 mm × 3–4 mm, red, with persisting calyx, 1-seeded. Seeds elongated, c. 10 mm long, with an aril.

Halopegia comprises 3 species, of which 1 occurs in mainland Africa, 1 in Madagascar, and 1 in South-East Asia.

Halopegia azurea is autogamous. The fruits are probably dispersed by water. Natural reproduction is through seed and rhizomes.

Ecology *Halopegia azurea* occurs from sea level up to 900 m altitude in marshy places by streams in forest.

Management It is not known whether *Halopegia azurea* is sometimes planted or only collected from the wild.

Genetic resources and breeding In view of its wide distribution, *Halopegia azurea* seems not in danger of genetic erosion.

Prospects The size of the leaves and the absence of active compounds make the leaves suitable for food wrapping. In addition, *Halopegia azurea* is a useful local source of material for thatching. The species may have potential for cultivation, and research on propagation and management practices seems worthwhile.

Major references Burkill, 1997; Hattori, 2006; Hepper, 1968c; Koechlin, 1965; Ley, 2008.

Other references Abbiw, 1990; Borchsenius & Suksathan, 2005; Bouquet & Debray, 1974; Hawthorne & Jongkind, 2006; Letouzey, 1982b; Ley & Claßen-Bockhoff, 2009; Lubini, 1994; Raponda-Walker & Sillans, 1961; Toirambe Bamoninga, 2007.

Authors M. Brink

HAUMANIA DANCKELMANIANA (J.Braun & K.Schum.) Milne-Redh.

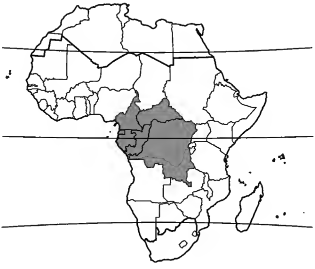
Protologue Kew Bull. 1950: 162 (1950).

Family Marantaceae

Origin and geographic distribution *Haumania danckelmaniana* is distributed in Cameroon, the Central African Republic, Equatorial Guinea, Gabon, Congo and DR Congo.

Uses The leaves are used for wrapping food to be baked. They are also made into a range of useful articles, such as cups, funnels and fans. After the prickles have been removed, the stems are used for making carrying devices, hut frames and traps. The split stem and stem bark are plaited into mats, baskets and knife sheaths. The debarked stem is used for making brooms. The prickles are used for grating cassava and wild yam. The roasted seeds are eaten and locally known as 'peanuts from the forest'. The bark is added to tobacco to strengthen the taste.

In traditional medicine in Cameroon the burnt and pounded root is mixed with palm oil and



Haumania danckelmaniana – wild

externally applied on sores and against headache, while the young leaves are applied on snake bites. In Central Africa the leaf sap is drunk as a purgative and against worms, or a decoction of the liana is applied in an enema.

Properties The stem bark is said to be very strong.

Botany Perennial, straggling or climbing herb up to 6 m tall, with rhizome; stem branched, densely covered with recurved prickles. Leaves alternate, imbricate; petiole sheathing for much of its length, 6–23 cm long (including sheath), glabrous, the uncalloused part and the apical calloused part not separated by a joint, transition of the petiole into the midvein marked by a beak on the upper surface, but continuous on the lower surface; blade ovate to ovate-lanceolate, more or less symmetric, up to 25(–27) cm × 12(–13) cm, base rounded to truncate, apex acuminate, pubescence confined to the base of the blade, parallel lateral veins numerous. Inflorescence a raceme, subtended by a lanceolate sheath 3–7 cm long; main axis zig-zag, with at each node an abaxial bract enveloping 3–6 cymules; abaxial bracts spreading at right angles to the rachis, folded, ovate, 1.5–2 cm long, with rounded apex, more or less persistent; cymules each with an adaxial bract, 2-flowered; common peduncle of cymules short. Flowers bisexual, zygomorphic, white, fragrant; bracteole absent; sepals 3, petaloid, free, equal, 3–4 mm long; corolla tubular below, with 3 lobes, tube 4–5 mm long, lobes c. 8 mm long; fertile stamen 1, staminodes petaloid and white with yellow spots; ovary inferior, hairy, 3-locular. Fruit a trigonous capsule c. 3 cm × 2 cm, with rounded angles, covered with conical protuberances. Seeds without aril.

The flowers of *Haumania danckelmaniana* are pollinated by bees and probably by sunbirds as well.

Haumania comprises 3 species, distributed in central Africa. The similarly used *Haumania liebrechtsiana* (De Wild. & T.Durand) J.Léonard can be distinguished from *Haumania danckelmaniana* by its stems without prickles, its abaxial inflorescence bracts 2.5–3.5 cm long, and its sepals c. 11 mm long.

Ecology *Haumania danckelmaniana* occurs in high-rainfall areas in primary and secondary forest, forest clearings, fallows and as a weed in plantations. The shoots and fruits are often eaten by lowland gorillas.

Management For the preparation of weaving material in Cameroon, the thorns are cut off the stem, which is then split, after which the pith is scraped off.

Genetic resources and breeding There are no indications that *Haumania danckelmaniana* is threatened by genetic erosion.

Prospects The leaves and stems of *Haumania danckelmaniana* are locally made into a range of useful articles. There are no reports of the species being overexploited, but the plant may have potential for cultivation for local use, and research on propagation and management practices may be worthwhile.

Major references Burkill, 1997; Hattori, 2006; Hepper, 1968c; Koechlin, 1965; Milne-Redhead, 1950.

Other references Betti, 2004; Bouquet, 1969; Cabezas et al., 2005; Koechlin, 1964; Ley, 2008; Neuwinger, 2000; Ngobo, Weise & Mcdonald, 2004; Nishihara, 1995; Terashima & Ichikawa, 2003; Van Dijk, 1997.

Authors M. Brink

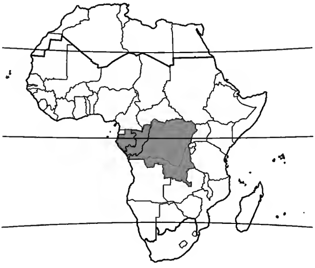
HAUMANIA LIEBRECHTSIANA (De Wild. & T.Durand) J.Léonard

Protologue Bull. Jard. Bot. Etat 19: 454 (1949).

Family Marantaceae

Origin and geographic distribution *Haumania liebrechtsiana* is distributed in Gabon, Congo, DR Congo and Cabinda (Angola).

Uses The leaves are used for wrapping food and other things. The stems are used for tying, for instance in house construction, for weaving and for making traps for small animals such as rats, crabs and fish. Split stems are used for making arrow cases. Split petioles are used as skewers. In traditional medicine, leaf ash is



Haumania liebrechtsiana – wild

applied for the treatment of scabies and burns, and seeds ground with kaolin are applied on abscesses.

Botany Perennial, liana-like herb up to 10 m tall or more, with rhizome; stem branched, hairy. Leaves alternate, imbricate; petiole sheathing for much of its length, apical calloused part 2–6 cm long, the calloused and uncalloused parts not separated by a joint, transition of the petiole into the midvein marked by a beak on the upper surface, but continuous on the lower surface; blade ovate-oblong, more or less symmetric, 10–30 cm × 6–15 cm, base rounded, apex acuminate, pubescence of the lower surface often confined to lines of hairs along the midvein. Inflorescence a raceme c. 10 cm long, subtended by lanceolate sheaths; main axis zig-zag, with at each node an abaxial bract enveloping 3–6 cymules; abaxial bracts ovate, 2.5–3.5 cm long, with acuminate apex, whitish; cymules each with an adaxial bract, 2-flowered; common peduncle of cymules short. Flowers bisexual, zygomorphic, white, fragrant; bracteole absent; sepals 3, petaloid, free, equal, 10–15 mm long; corolla tubular below, with 3 lobes, tube 7 mm long, lobes 10–12 mm long; fertile stamen 1, staminodes petaloid and white with yellow spots; ovary inferior, densely hairy, 3-locular. Fruit an indehiscent, round capsule, becoming 3-lobed upon drying, covered with rounded protuberances, yellow. Seeds black, without aril.

Haumania comprises 3 species, distributed in central Africa. The similarly used *Haumania danckelmaniana* (J.Braun & K.Schum.) Milne-Redh. can be distinguished from *Haumania liebrechtsiana* by its stems with prickles, its abaxial inflorescence bracts 1.5–2 cm long, and its sepals 3–4 mm long.

Ecology *Haumania liebrechtsiana* occurs in primary and secondary forest, along streams and in inundated locations. In the Lopé reserve (Cameroon) densities of over 25,000 stems per ha have been recorded. The shoots are an important food of gorillas, chimpanzees and bonobos, and the immature seeds are also eaten.

Genetic resources and breeding There are no indications that *Haumania liebrechtsiana* is threatened by genetic erosion.

Prospects The leaves and stems of *Haumania liebrechtsiana* are locally made into a range of useful articles. There are no reports of the species being overexploited, but the plant may have potential for cultivation for local use, and research on propagation and management practices may be worthwhile.

Major references Hepper, 1968c; Koechlin, 1964; Lubini, 1994; Milne-Redhead, 1950; White et al., 1995.

Other references Bouquet, 1969; Dowsett-Lemaire, 1996; Evrard & Bamps, 1959; Koni Muluwa & Bostoen, 2008b; Neuwinger, 2000; Raponda-Walker & Sillans, 1961; Reinartz et al., 2006; Takeda, 1990; Takeda, 1996; Terashima, Kalala & Malasi, 1991.

Authors M. Brink

HELICTONEMA VELUTINUM (Afzel.) Pierre ex N.Hallé

Protologue Thèses Fac. Sci. Univ. Paris, Monogr. Afr. Occ.: 48 (1958).

Family Celastraceae (Hippocrateaceae)

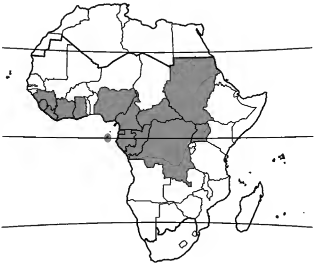
Synonyms *Hippocratea velutina* Afzel. (1813).

Vernacular names Bois charbon (Fr).

Origin and geographic distribution *Helictonema velutinum* is distributed in the more humid regions of mainland tropical Africa, from Guinea eastwards to Sudan, Uganda and DR Congo. It is also recorded in Angola but from Cabinda only.

Uses In Ghana, and probably elsewhere in West Africa, the young branches of *Helictonema velutinum* are used as a binding material. In Sierra Leone the leaves are processed by drying, pounding and boiling and are applied as a poultice to the temples to cure headache. The medicinal use of the seeds to cure headaches reported for Senegal is probably incorrect as the species does not occur there.

Botany A tall liana up to 30 m tall; main stem over 10 cm in diameter, swollen at nodes;



Helictonema velutinum – wild

bark coarsely scaly, longitudinally grooved, greyish yellow; young branches densely stellate-hairy, reddish-brown. Leaves opposite, simple; stipules small; petiole hairy, 6–12 mm long; blade (oblong-)elliptical, 5–15 cm long, subcordate to rounded at base, shortly acuminate, margin entire, sparsely hairy above, soft-hairy below, discolorous, with 4–8 pairs of secondary veins. Inflorescence a large, axillary panicle consisting of paired cymes, usually reddish soft-hairy; peduncle of cymes 2–10 cm long, with up to 6 branches. Flowers bisexual, yellowish or white, 12–15 mm in diameter; pedicel 4–10 mm long; sepals c. 4 mm × 2.5 mm, recurved, fawn-coloured, soft-hairy on both sides; petals 5, free, ovate, 5–7 mm × 4 mm, conspicuously fimbriate; disk 20–30-lobed, 5–7 mm in diameter, dark green, with androgynophore; stamens 3, filaments widened at base and bent outward; ovary short-hairy, 3-celled, style punctiform. Fruit consisting of 3 cylindrical mericarps 7 cm × 3 cm, dry, dehiscent, with short brown hairs. Seeds densely short-hairy, with an ovate or oblong, glabrous wing with 2 marginal veins. Seedling with hypogeal germination.

In West Africa *Helictonema velutinum* flowers in July–November. *Helictonema velutinum* is the only species in the genus *Helictonema*.

Ecology *Helictonema velutinum* occurs in thickets, forest margins, gallery forest and rainforest from sea-level up to 1100 m altitude.

Genetic resources and breeding As *Helictonema velutinum* does not appear to be heavily exploited and is widely distributed there is probably no danger of genetic erosion.

Prospects *Helictonema velutinum* will remain a species of local interest only, for the binding material it supplies and for its medicinal use.

Major references Burkill, 1985; Hallé, 1962; Irvine, 1961.

Other references Hawthorne & Jongkind, 2006; Keay & Blakelock, 1958; Lebrun & Stork, 2010; Neuwinger, 2000; Robson et al., 1994; Simmons & Hedin, 1999.

Authors C.H. Bosch

HETEROPOGON CONTORTUS (L.) P.Beauv. ex Roem. & Schult.

Protologue Syst. Veg., ed. 15 bis, 2: 836 (1817).

Family Poaceae (Gramineae)

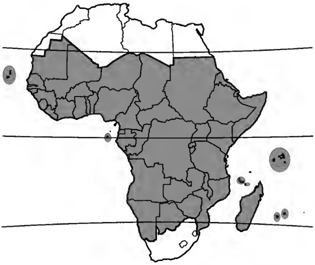
Chromosome number $2n$ = 20, 36, 39, 40, 44, 50, 58, 60, 70, 80, 90. Tropical genotypes are predominantly tetraploid, while subtropical ones range from tetraploid to nonaploid.

Synonyms *Andropogon contortus* L. (1753), *Heteropogon hirtus* Pers. (1807), *Heteropogon hispidissimus* A.Rich. (1851).

Vernacular names Speargrass, black speargrass, bunch speargrass, tangle grass, tanglehead grass, tanglehead, assegai grass, pili grass (En). Herbe polisson, herbe barbue, herbe à moutons (Fr). Flechinha (Po). Kichoma mguu, kichoma nguo, kishona nguo, kishona (Sw).

Origin and geographic distribution *Heteropogon contortus* is native to the tropics and subtropics of Africa, southern Asia, northern Australia and parts of Oceania. It is widely naturalized in tropical and subtropical regions of the Americas, East Asia and Oceania. It is grown in Australia, India, South America and the United States. In tropical Africa it is commonly found from Cape Verde, Mauritania and Senegal eastwards to Eritrea and Somalia and southwards to Angola, Mozambique, South Africa, and in the Indian Ocean islands.

Uses *Heteropogon contortus* is used as thatch for huts and is commonly woven into mats. The cellulose content of the grass is quite high and it has been examined for pulping for paper manufacture, but with poor results. *Heteropogon contortus* is a good forage and fodder grass when young, but very troublesome to man and animals and even injurious to the latter after flowering because of the sharp-pointed seeds which may penetrate the skin and the membranes of the mouth and intestines. Also, the awns entangle with the fur of animals, especially the fleece of sheep. A second limitation to animal production is the



Heteropogon contortus – wild

wide fluctuation of herbage growth and quality between wet and dry seasons. The grass is mainly used as part of the natural savanna pasture. Young herbage can be conserved as hay or silage. *Heteropogon contortus* could be planted for erosion control and revegetation of degraded habitats. Zulu people in South Africa use the plant in the treatment of burns, wounds and rheumatism. The plant also is diuretic. In Benin a decoction of the inflorescence is a component of a medicine drunk against irritability. In Zambia bees have been observed visiting the plant for pollen.

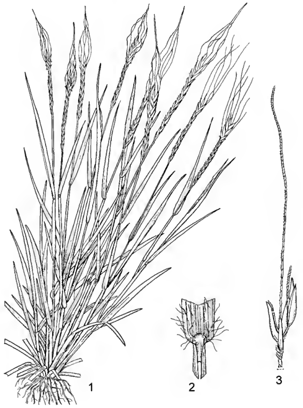
Production and international trade *Heteropogon contortus* is only used locally.

Properties Tests in India showed that *Heteropogon contortus* grass can yield about 48% unbleached pulp using a soda pulping process with a kappa number of 22.0–27.2 without enzyme and 20.6–26.0 with enzyme. Handmade test pulp sheets with adequate strength properties were obtained from soda pulp.

As forage, the grass is palatable in the early vegetative stages, but intake and digestibility decline rapidly as it matures. By the end of the growing season, it is only eaten if supplemented with urea and molasses. In unimproved pasture the dry-matter protein content ranges from 10% in very young green material from the early flush of the growing season to about 5% during much of the growing season and to as low as 1% in dry forage by the end of the dry season. These levels are lower than those in species such as *Panicum maximum* Jacq. and *Chloris gayana* Kunth. Crude protein levels are not raised greatly by application of fertilizer nitrogen. Experiences from India showed that the crude protein content of a *Heteropogon* community was about 5% when untreated, and 5.8% when fertilized with nitrogen. Phosphorus levels in the dry matter range from 0.09–0.15%, and calcium from 0.23–0.30%. In plants at early bloom with 34% dry matter and 6.6% crude protein, acid detergent fibre (ADF) was 22% and neutral detergent fibre (NDF) 52%. In mature plants corresponding values were dry matter 42%, crude protein 4.4%, ADF 32% and NDF 64%. Digestibility varies similarly from 60% down to 40%. The sharply pointed and barbed seeds are an additional drawback.

A study conducted on indigenous grasses in Botswana showed that the dry matter content of hay made of various grasses was highest in *Heteropogon contortus* (78.4% in June and 85.7% in the rainy season in December). However, its crude protein content was lowest, and decreased from 4.9% in June to 1.3% in December. The study confirmed that during the dry season, the dry matter and fibre content (neutral detergent fibre and acid detergent fibre) increased, while the crude protein content of the grass decreased. Digestibility also decreased during the dry season. The mineral content of the grass was lower than average except for calcium.

Description Tufted perennial grass 0.5–1.5 m tall, rather variable in habit; stems erect to geniculate at the base, often branched above, particularly at flowering, flattened towards the base, glabrous, smooth; nodes smooth and glabrous. Leaves basal and on the culm, green or bluish; leaf sheath smooth, compressed, keeled, striate, sometimes with a few hairs near the ligule; ligule a short, membranous rim; blade linear, 3–30 cm × 2–8 mm, folded in the lower part, becoming flat, slightly rough to the touch with a few long hairs particularly towards the base, apex blunt, almost canoe-shaped. Inflorescence a simple raceme of pairs of spikelets arranged in 2 rows, 3–8 cm long (excluding the awns), the outermost ones pedicellate and overlapping and enclosing the innermost sessile spikelets; at the base of the raceme the spikelets are similar and unawned, male or sterile,



Heteropogon contortus – 1, flowering plant; 2, ligule; 3, two pairs of heterogamous spikelets. Source: PROSEA at the top the spikelets are dissimilar, comprising sessile, bisexual, awned spikelets and pedicellate, male or sterile, unawned spikelets; sessile spikelet 2-flowered, 5–10 mm long, with a pungent and bearded callus 2–3 mm long, glumes as long as spikelet, lower glume 5-veined, upper glume 3-veined, lower lemma c. 1/2 the length of the spikelet, sterile, without a palea, upper lemma stipe-like at the base and passing into a twisted awn 5–10 cm long, stamens 3, stigmas 2, purple; pedicellate spikelet unawned, 5–15 mm long, glumes sometimes hairy and enclosing reduced lemmas, the base of the spikelet bearing a callus 2–3 mm long; spikelets at the base of the raceme resembling the pedicelled spikelets. Fruit a caryopsis (grain), cylindrical, 3.5–4.5 mm long, grooved, whitish.

Other botanical information *Heteropogon* is a member of the tribe *Andropogoneae*. It comprises 6 species and occurs throughout the tropics, extending to warm temperate regions. *Heteropogon contortus* is extremely diverse in habit and hairiness of the spikelets, and is adapted to a wide range of rainfall regimes. The narrowly cylindrical racemes of overlapping green spikelets, with stout brown intertwining awns emerging from the upper part, are very characteristic of this species. *Heteropogon contortus* is apomictic, producing seed with vegetatively formed embryos, but sexual reproduction also occurs. This has led to a considerable amount of localized variation, resulting in the proliferation of local species and varieties in the early botanical literature. An annual form has been described from India, but this could be a short-lived perennial form growing in a difficult environment.

Heteropogon melanocarpus (Elliot) Benth. ('sweet tanglehead') is an annual grass up to 2 m tall, occurring from southern China westward through tropical and subtropical Asia and tropical Africa to the tropical and subtropical parts of America. Like *Heteropogon contortus* it is used for grazing when young.

Growth and development *Heteropogon contortus* is a relatively short-lived perennial. Grazing pressure influences survival of individual tussocks. Under light grazing, individual plants can live for several years.

Heteropogon contortus exhibits a high degree of embryo and seed-coat dormancy in freshly ripened seed. This declines over the dry season to a high level of germination at the first rains of the next wet season. Subsequently, the germination rate falls off rapidly with little or no survival beyond one year. Seeds which are burrowed into the soil are in a favourable environment for germination. In a stand there can be over 5000 seeds per square meter. Flower initiation is obligatory to facultatively short day, the former being characteristic of the tropical forms, which flower late in the wet season, and the latter of the subtropical forms which flower early to mid season. The late flowering forms have higher leaf yields and are more responsive to increased soil fertility.

Heteropogon contortus is largely dormant during the cooler, drier months. Vegetative growth begins when both temperature and soil moisture levels are adequate. In an area in south-western Zimbabwe where *Heteropogon contortus* is the dominant component of natural grassland, it was found to be very sensitive to the availability of soil moisture. Growth was vigorous after significant rainfall, but slowed or ceased after 2–3 dry weeks. When rain returned, rapid growth of green leaves resumed as tillers continued growth. Peak shoot yield varied greatly from year to year, and was attained near the end of the growing season as soil moisture was depleted. Shoot yields then declined, primarily as a result of litter fall. Plants tend to be weakly rooted late in the dry season. *Heteropogon contortus* uses the C_4 photosynthetic pathway.

Ecology As a typical member of the *Andropogoneae*, *Heteropogon contortus* is a savanna grass growing in seasonally warm wet and cooler dry climates. It is most abundant in the understorey of various woodlands and open forests such as *Combretum-Terminalia* woodland. *Themeda triandra* Forssk. and species of *Bothriochloa*, *Eragrostis*, *Aristida*, *Chloris* and *Chrysopogon* are common associates of *Heteropogon contortus*. It often forms nearly pure stands. It appears not to be dominant in undisturbed climax vegetation, but may become so through habitat disturbance such as heavy grazing and burning, particularly in Australia, India and Africa.

Heteropogon contortus tolerates light shade and often dominates the understorey of *Eucalyptus* woodlands in tropical and subtropical Australia, but is much less shade tolerant than *Panicum maximum* Jacq. It is most abundant where annual rainfall averages 600–1000 mm, and where there are marked wet and dry seasons, but is also found well outside these limits, such as on parts of the Big Island of Hawaii with an average annual rainfall of only 210 mm. It does not tolerate long periods of flooding, but can tolerate a few days' inundation on otherwise well-drained soils. It does not tolerate high salinity. *Heteropogon contortus* occurs over a wide range of average annual temperatures, from 28°C near sea-level in Sri Lanka to 11°C at an altitude of 3800 m in Peru and 15.5°C at 1300 m in South Africa. *Heteropogon contortus* is moderately frost tolerant, although plants are usually mature by the time of the first frosts.

Heteropogon contortus grows on a wide variety of soils, ranging from sandy loam to clay loam and soil type plays only a minor role in determining distribution. It can grow on infertile sands and strongly layered soils but also on very fertile clay loams. It is much less common on some heavy clay soils, soils with poor drainage, under conditions of extremely low fertility and in saline situations. *Heteropogon contortus* generally prefers sandy loams with pH 5.0–6.0.

Propagation and planting *Heteropogon contortus* can be propagated by seed or vegetatively. Seed cleaning is difficult because the awn and callus are not easily removed without damaging the seed, while without the removal of the awn and callus, sowing is difficult. Since commercial seed is scarce, most small-scale establishment has been vegetative using splits of mature plants. Seed should be sown no deeper than about 1 cm, preferably into a fine, firm and clean seedbed, and rolled after sowing. The 1000-seed weight is 7 g with awns, and 2 g without awns. Because fresh seed shows dormancy, seed should be stored for 6–12 months before sowing. In nature, the twisting action of the hygroscopically active awns and the sharp, barbed tip of the seed play an important role in pushing the seed into the soil. Disturbances increase recruitment of the seedlings. The optimum temperature for germination is 30–35°C, while germination is inhibited by night temperatures of 15–20°C. Seedlings do not compete well against better adapted species in recently cultivated, N-rich soils.

Management In its natural state in savanna, *Heteropogon contortus* has a relatively short period of growth and adequacy for livestock nutrition. This causes a large part of the annual biomass production to become unusable and to be left as dry standing material. Commonly this material is burnt during or at the end of the dry season. This procedure leads to increasing dominance of *Heteropogon contortus* in the vegetation, especially in conjunction with grazing. Burning is also commonly used to maintain *Heteropogon contortus* pastures. Crops can be shredded or burned on an annual basis or once every 2–3 years. However, burning during the dry season may reduce nutrient availability.

Under continuous heavy grazing, *Heteropogon contortus* declines, and can be reduced to a minor component of pastures, particularly on poor soils or where high stocking rates are sustained through supplementary feeding. It is most susceptible to grazing in the early part of the wet season. One recommendation for long-term maintenance of *Heteropogon contortus* pastures is that utilization rates should not exceed 30%.

Although it is adapted to low-nutrient soils, an up to 8-fold improvement of livestock production from natural *Heteropogon contortus* pastures can be achieved by introducing tropical legumes such as *Stylosanthes* spp., or *Macroptilium atropurpureum* (DC.) Urban in the subtropical zones. This improvement comes from both increased carrying capacity and rate of growth of the livestock. However, care must be taken, especially in the more strongly seasonal tropics, to avoid overgrazing as a result of the increased stocking rates. Moderate levels of fertilizer application benefit growth and rapid establishment, but high levels of fertilizer nitrogen can kill plants. In India, application of 20 kg N/ha raised dry matter production from 3340 kg/ha to 4330 kg/ha, while 40 kg N/ha raised it to 5560 kg/ha. If sown with a legume, application of phosphate fertilizer can benefit the legume component, and reflect in improved animal performance. For rotational grazing, a forage height of 10–25 cm should be utilized. It is recommended that 15 cm is maintained as a minimum stubble height under continuous grazing. *Heteropogon contortus* does not develop seed if it is consistently grazed, and populations will decrease if grazing is too heavy. In Queensland (Australia), the carrying capacity of native *Heteropogon contortus* pastures is one animal to 3.5–4 ha in the southern area and to 8–10 ha in the north of the region. Cattle lose weight in the winter and spring and take 4–5 years to reach market weight.

Diseases and pests Several smut diseases of the inflorescence have been reported on *Heteropogon contortus*. A recent revision placed them all in the genus *Sporisorium*. Ergot (*Claviceps* spp.) may affect seed production, particularly under cool, moist conditions. Leaf rust caused by *Puccinia versicolor* or *Uromyces clignyi* is common on more mature leaves. *Hetero-*

pogon contortus acts as a collateral host for downy mildew caused by *Peronosclerospora sorghi* on sorghum and maize. Rice shoot fly (*Atherigona oryzae*) has been recorded as a pest of *Heteropogon contortus*.

Harvesting *Heteropogon contortus* can be harvested with brush or beater harvesters to get hay-bales containing viable seed, which can be used for rehabilitation purposes. Since the panicles have a tendency to tangle when mature, harvesting can also be done easily with a 'pili comb'

Yield In India dry matter yields up to 5560 kg/ha have been reported.

Genetic resources While *Heteropogon contortus* is mainly used in natural stands, a few named selections are available, such as 'Rocker' from Arizona and 'Kahoolawe' from Hawaii. *Heteropogon contortus* is not threatened with genetic erosion as it occurs widely over the world. Its genetic diversity is also preserved in germplasm collections, e.g. at the Southern Regional PI Station, Griffin, Georgia of the USDA/ARS National Genetic Resources Program, and in Indonesia, Ethiopia and Zimbabwe. A study using RAPD markers to assess genetic variation within and among Hawaiian populations, found 55 unique genotypes among 56 individuals sampled from six populations on Oahu and Hawaii. This diversity suggests frequent sexual reproduction in these populations. No African populations have been studied so far.

Breeding There are no known breeding programmes of *Heteropogon contortus*. While there is considerable genetic variability for selection, there are two serious obstacles to breeding: it is apomictic and it has a most unpractical seed morphology for easy seed production.

Prospects *Heteropogon contortus* will remain an important forage in natural grasslands, especially in Africa, Australia, and India. Because of the sharply barbed seed, risk of overgrazing and strongly seasonal growth, careful management is needed. Commercial seed production remains difficult. It is likely to remain a source of thatch and mat-making material of local importance.

Major references Aganga, 2005; Carino & Daehler, 1999; Clayton, Harman & Williamson, 2002–; Clayton & Renvoize, 1982; Cook et al., 2005; Georgen & Daehler, 2002; Phillips, 1995; Tothill, 1966; Tothill, 1968; Tothill & Hacker, 2006.

Other references Burkill, 1994; Chhetri, Kumar & Kathirvelu, 2010; Hendricksen et al., 2010; Hunter & Siebert, 1986; Leithead, Yarlett & Shiflett, 1976; Lowry, Kennedy & Conlan, 2002; Melzer et al., 2010; Neuwinger, 2000; Orr et al., 2001; Paswan et al., 2008; Piatek, 2006; Ripley, Frole & Gilbert, 2010; Skerman & Riveros, 1990; Tefera, Dlamini & Dlamini, 2010; Tothill, 1992; Tothill et al., 1985; Vánky, 2000; Wang & Qiu, 2006; Wilson & Kennedy, 1986.

Sources of illustration Tothill, 1992.

Authors T. Soromessa

HIBISCUS CANNABINUS L.

Protologue Syst. nat. ed. 10(2): 1149 (1759).

Family Malvaceae

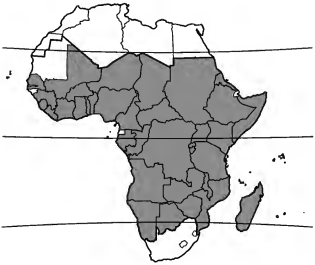
Chromosome number $2n = 36$

Synonyms *Hibiscus sabdariffa* L. subsp. *cannabinus* (L.) G.Panigrahi & Murti (1989).

Vernacular names Kenaf, vegetable kenaf, Guinea hemp, Deccan hemp (En). Kénaf, chanvre de Guinée, chanvre de Bombay, da (Fr). Nacacha, nhacandora, cânhamo brasileiro (Po).

Origin and geographic distribution *Hibiscus cannabinus* is a common wild plant in most African countries south of the Sahara. It may have been domesticated as a fibre plant already 6000 years ago in Sudan. Kenaf is now widespread in the tropics and subtropics. As a vegetable it is widely grown in Africa, where it is grown on a much smaller scale as a fibre crop. In the past it has been of some importance as a commercial fibre crop in Côte d'Ivoire, Burkina Faso, Togo, Benin, Niger, Kenya, Tanzania and Malawi. India has long been the largest producer of kenaf fibre.

Uses The shoots or young leaves, and some-



Hibiscus cannabinus – wild and planted times the flowers and young fruits, are used as a vegetable. In Uganda a local delicacy is made from the seeds. These are roasted, ground and pounded, and the flour and skin are separated in water. The flour is rejected but the floating skin parts are used for the preparation of a paste, mixed with boiled pigeon peas. Children chew the bark for its sweetness.

The stem is a source of fibre used in the manufacture of twine, rope and coarse textiles for sacking and cloth for packaging; special fibre cultivars exist. The production of kenaf fibre in Africa is rather uncommon, but locally important, e.g. in northern Nigeria, Niger and Sudan, where it is used for cordage, twines, fishlines and nets. Dried scraped ribbons are used for twine and cordage for sleeping mats. Ribbons and whole stems are a raw material for the pulp and paper industry. Seeds from the fibre crop are used for oil extraction, the rest being used as feed. The oil is suitable as a lubricant and for illumination, for manufacture of soap, linoleum and in paints and varnishes.

In local medicine in Kenya, pounded roots are administered to spider bites, and leaves are used to treat stomach disorders. In West Africa, powdered leaves are applied to sores and boils, and a leaf infusion is administered for treating cough. In India, juice from the flowers is taken against biliousness, while the seed are considered stomachic and aphrodisiac. Whole young plants are an excellent fodder for cattle. The stem core (xylem) is used in combination with peat moss (*Sphagnum*) and fertilizers as a growth medium for plants. Kenaf plants accumulate minerals such as selenium and boron and can be used as a bioremedial tool for removing these metals from contaminated soil. In West Africa the plants are used as boundary markers.

Production and international trade Kenaf leaves are sold at local markets in West and Central Africa. Statistics on production and trade as a vegetable are not readily available.

The average annual world production in 2004–2008 of jute-like fibres, a group including, among others, kenaf, roselle (*Hibiscus sabdariffa* L.), Congo jute (*Urena lobata* L.), sunn hemp (*Crotalaria juncea* L.) and devil's cotton (*Abroma augusta* (L.) L.f.), was about 350,000 t, harvested from 250,000 ha. Separate statistics of these species are not available, but kenaf makes up a large part of the total, with India as main producer. In Africa, production is limited and practically all kenaf fibre is produced domestically. Industrial production is reported from Nigeria and Sudan.

Properties The composition of kenaf leaves per 100 g edible portion is: water 79.0 g, energy 280 kJ (67 kcal), protein 5.5 g, fat 1.2 g, carbohydrate 12.2 g, fibre 2.3 g, Ca 484 mg, P 18 mg, Fe 12.1 mg, ascorbic acid 75 mg (Leung, Busson & Jardin, 1968). The composition of kenaf leaves is comparable to other dark green leafy vegetables.

Kenaf produces a bast fibre similar to jute, but with a greater tensile strength, somewhat coarser and more brittle. On a dry weight basis the bast fibre content of the stem ranges from 21% in wild accessions up to 36% in modern cultivars. Individual bast fibres are (1.5–)2–3(–12) mm long and (7–)15–25(–41) μm in diameter with a cell wall thickness of 4–9 μm. In cross-section they are polygonal to round or oval, with a varying lumen width. In longitudinal section the fibre cells are cylindrical. The fibre ends show great variation, but most often they taper into a blunt point. The fibre strands of commerce, consisting of fibre cells cemented together by pectin and hemicelluloses, are 1.5–3 m long. Kenaf fibre contains 36–62% α-cellulose, 14–21% hemicelluloses, 6–19% lignin, 1–5% pectin and 0–3% ash. The tensile strength, elongation at break, and Young's modulus of kenaf fibre are 295–1190 N/mm^2, 3.7–6.9% and 22,000–60,000 N/mm^2, respectively.

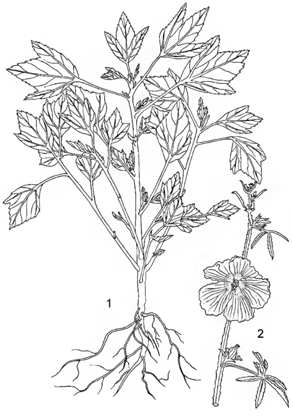
The fibre cells in the woody core are (0.4–)0.5–0.9(–2.4) mm long and 18–33(–37) μm in diameter, with an average cell wall thickness of 4–8 μm. The length of both bast and core fibre cells increases from the base to the top of the stem. Whole stems contain 77–79% holocellulose, 37–50% α-cellulose, 16–20% lignin and 2–4% ash. The core fraction contains 65–72% holocellulose, 34–39% α-cellulose, 24–29% hemicelluloses, 14–20% lignin and 2–6% ash.

Paper made from kenaf bast fibre by chemical pulping is stronger than paper from softwood pulp; paper made from whole stems by chemical pulping has strength properties between paper made from chemical pulp from softwood and that made from hardwood; it is comparatively tight and nonporous compared to paper made from wood.

Seeds contain up to 22(–26)% oil, with a fatty acid composition of palmitic acid 14–20%, stearic acid 3–7%, oleic acid 28–51% and linoleic acid 23–46%. The oil has phytotoxic and fungitoxic properties. The presscake contains: moisture 9%, crude protein 32%, oil 8%, crude fibre 8% and practically no antinutritional components.

Adulterations and substitutes Kenaf leaves in dishes can be replaced by roselle (*Hibiscus sabdariffa*) or other leafy vegetables.
For many purposes, such as packaging and cordage, kenaf, jute (*Corchorus* spp.), roselle (*Hibiscus sabdariffa*) and congo jute (*Urena lobata*) may be substituted for each other, although kenaf and roselle are coarser and therefore cheaper than jute.

Description Annual herb, up to 2 m tall in the wild, up to 5 m in cultivars; taproot well developed, with lateral roots spreading horizontally to 1 m and adventitious roots on lowest stem section; stem erect, slender, cylindrical, prickly on wild accessions. Leaves alternate, simple; stipules filiform, 5–8 mm long, pubescent; petiole 3–30 cm long; blade 1–19 cm × 0.1–20 cm, very shallowly to very deeply palmately 3–7-lobed in lower part of plant, often unlobed in upper part or even bractlike near the apex, base cuneate to cordate, apex acuminate, margins serrate or dentate, upper surface glabrous but with a prominent, 3 mm long nectary at the base of the midrib, lower surface hairy along the veins. Flowers axillary, solitary or sometimes clustered near the apex of the plant, bisexual, 5-merous, 7.5–10 cm in diameter; pedicel 2–6 mm long, articulated at the base; epicalyx of 7–8 linear segments 7–18 mm long, persistent; calyx campanulate with acuminate to subcaudate lobes 1–2.5 cm long (up to 3.5 cm in cultivars), persistent, green, bristly and with a characteristic white, woolly, arachnoid tomentum especially near the base and margins, with a prominent nectary gland on each midrib; petals free, usually spreading, twisted clockwise or anticlockwise, obovate, 4–6 cm × 3–5 cm, outer side stellate-pubescent, usually cream to yellow with red inner base, sometimes blue or purple; stamens numerous, filaments united into a column surrounding the style, 17–23 mm long, dark red, with yellow or red anthers; ovary superior, ovoid, villose, 5-celled, style branching into 3–5, hairy arms 2–4 mm long, each branch ending in a capitate stigma. Fruit an ovoid, shortly beaked capsule 12–20 mm × 11–15 mm, densely appressed pubescent, 20–25(–35)-seeded. Seeds reniform to triangular with acute angles, 3–4 mm × 2–3 mm, grey to brown-black with pale yellowish spots, hilum brown. Seedling with epigeal germination.



Hibiscus cannabinus – 1, habit of young plant; 2, flowering shoot.
Redrawn and adapted by Achmad Satiri Nurhaman

Other botanical information *Hibiscus* comprises 200–300 species, mainly in the tropics and subtropics, many of which are grown as ornamentals. The estimated number of species varies because opinions differ about inclusion or exclusion of several related groups of species in the genus. Kenaf belongs to *Hibiscus* section *Furcaria*, a group of about 100 species which have in common a pergamentaceous calyx (rarely fleshy) with 10 strongly prominent veins, 5 running to the apices of the segments and bearing a nectary, and 5 to the sinuses. Interspecific hybridization has been attempted with variable success between *Hibiscus cannabinus* and other species within the same section, such as *Hibiscus sabdariffa* L., *Hibiscus radiatus* Cav., *Hibiscus diversifolius* Jacq. and *Hibiscus acetosella* Welw. ex Hiern.
Hibiscus cannabinus can easily be distinguished from the related species *Hibiscus sabdariffa* by the white, arachnoid tomentum on the calyx. *Hibiscus cannabinus* is very variable and various subclassifications have been proposed, but none is generally accepted. The vegetable types such as 'Malakwang' grown in Uganda have a bushy form.

Growth and development In general kenaf is an obligate short-day plant. Flowering is influenced by the time of planting; long days and high temperatures prolong the vegetative growth phase, an advantage for vegetable and fibre crops. Most cultivars remain vegetative until the photoperiod falls below 12.5 hours. In Ghana, day-neutral early maturing varieties exist that take 45–56 days from sowing to flowering.

Kenaf is mainly an out-breeding plant, but up to 30% self-pollination occurs. Flowers open before daybreak and begin to close about midday. The flower structure promotes cross-pollination. The pistil is functional when the flower opens, while the stamens are not dehiscing until shortly after sunrise. While the pistil is still functional, the stigmatic lobes hang down, almost touching the unopened anthers. Later in the day, the stigmatic lobes become turgid and soon stand above the anthers, which lose their pollen. Cross-pollination is mainly effected by insects such as bees. Seeds ripen in about 5 weeks after anthesis. In wild and vegetable types the fruit wall bursts and the seeds are spread on the ground, whilst in fibre types the fruits are indehiscent.

Ecology Kenaf grows naturally in grassland and as a weed in fields and wasteland. It is grown from sea level up to an altitude of 2700 m but does not do well above 2500 m and does not tolerate frost. It does well at day temperatures between 16°C and 27°C with 500–650 mm rainfall distributed over a period of 4–5 months. Lower temperatures retard plant growth. It does best on well-drained, neutral sandy loams, rich in humus. It does not tolerate waterlogging.

Propagation and planting Kenaf is usually propagated from seed but may also be propagated through cuttings. Seed yield is 1–28 g/plant; the 1000-seed weight 25–27 g, in wild forms only 9–12 g. Under ordinary storage conditions at ambient temperatures and humidity, seeds remain viable for about 8 months. The optimum temperature for seed germination is about 35°C. In home gardens or on small plots of vegetable kenaf, seeds are sown two or three at a time, at spacings of 15 cm × 15 cm. This system is also used when interplanting with other crops. Commercial farmers may broadcast the seed for a crop that will be uprooted once the stems are 20–30 cm long. For ratoon cropping farmers usually sow in rows 30 cm apart. After a first thinning the within-row spacing is 5–7 cm. Germination of untreated seed takes about 7 days, longer than for most vegetables; for this reason some farmers soak their seed in water for 24 hours prior to sowing, obtaining emergence after 3 days. The latter method can only be used when rain is expected soon after sowing or when irrigation facilities are available.

For fibre production kenaf is broadcast at a seed rate of 15–30 kg/ha or drilled at a spacing of 15–30 cm between rows and a 3.5–10 cm within rows, but somewhat wider to produce fibre for making paper. Broadcast crops require thinning to about 400,000 plants/ha.

Management Kenaf responds well to fertilizers and organic manure, but only farmers producing for the market are prepared to invest in this crop. Manure at a rate of 10–20 t/ha is preferred, but if it is not available, an initial application of 250 kg/ha compound fertilizer (e.g. NPK 15–15–15) is recommended. An additional application of nitrogen as side dressing of 50 kg/ha is needed after the first cutting, and this can be repeated after every harvest. Ratoon crops can be picked up to five times when adequate fertilizer is provided. Kenaf may be grown alone or intercropped with other plants. In some regions it is semicultivated as a protected weed for use as a vegetable.

Kenaf grown for fibre grows rapidly and requires little weeding after the first month after sowing.

Diseases and pests Diseases and pests of vegetable kenaf are the same as reported for the fibre crop, and most of them are also similar to these of cotton and okra. The main diseases are: foot, stem and collar rot and wilting caused by *Phytophthora*; *Sclerotium rolfsii* causing collar rot; powdery mildew caused by *Leveillula taurica*; *Coniella musaiaensis* causing leaf spot; *Selenosporella* species causing root rot and wilting; *Rhizoctonia solani* causing stem rot and lodging; *Pythium deliense* causing root rot; *Phomopsis* species causing stem spot; *Verticillium dahliae* causing wilting; *Fusarium oxysporum* causing wilting and necrosis; tobacco necrosis virus (TNV); and hibiscus latent ringspot virus (HLRSV), which is seed transmitted.

The cotton flea beetle *Podagrica puncticollis* is a notable pest, most serious in the seedling stage. *Oxycarenus* spp. and *Dysdercus superstitiosus* are seed infesting bugs. Kenaf is especially susceptible to root-knot nematodes (*Meloidogyne* spp.) that may reduce growth and yield especially on light-textured soils. Nematodes also predispose affected plants to pathogenic soil fungi. In order to control nematodes, crop rotation is recommended especially with amaranth or a cereal crop, and liberal application of organic fertilizer. Chemical spraying for control of pests and diseases is rarely applied.

Harvesting Vegetable kenaf takes 3–4 weeks from emergence to the first harvesting. As a first thinning, plants of about 20 cm are pulled up and marketed with their roots attached. When ratoon cropping is practised, the second harvest is at the 6-week stage, 2–3 weeks after the thinning round. Cutting is done at a height of 6–8 cm, leaving 3 leaves and buds for regrowth. Up to 4–5 harvests may be carried out at 2–3-week ratooning intervals. After that, the remaining loose leaves are collected for home consumption. In commercially grown broadcast crops whole plants are pulled up when 20–30 cm tall and are sold at the market with their roots attached.

The recommended time of harvesting kenaf as a fibre crop for an optimum balance in fibre yield and quality is when about 50% of the plants are flowering. Plants are cut near the ground and tied into loose bundles that are placed upright in the field for 2–3 days to induce defoliation and drying. Stems are then graded and tied into bundles of about 10 kg and of even stem thickness.

Yield The yield for once-over harvest as a vegetable by uprooting is 20–30 t/ha. For ratoon cropping, a total of 60 t/ha is feasible from 5 harvest rounds, depending on soil fertility and moisture. The highest yields are obtained from the second and third cuts.

World yield of kenaf as a fibre crop averages about 1.2 t dry fibre per ha. The potential yield, obtained in experimental fields with improved cultivars, is 3–5 t dry fibre per ha.

Handling after harvest Fresh shoots are easily transported and can be kept in good condition for 1–2 days especially in shade or cool places. Sprinkling with water helps to keep the leaves fresh. Leaves can be preserved by sun-drying. The dried product is broken into small pieces or ground to powder and used in soups.

For fibre production kenaf stems are usually retted in clear and slow-moving water for a period of 10–15 days at temperatures around 30°C to liberate the fibres from the bark. Sometimes stems are decorticated ('ribboned') and only the ribbons are steeped in water, cutting retting time by half. When retting is complete, the fibres are stripped manually from the stems, washed thoroughly in clean water and dried well in dust- and sand-free conditions. The dried fibres are transported in crude bales of 60–150 kg to the spinning mills.

Whole stems may also be transported to pulp- and paper-making factories. Kenaf can be pulped by chemical, semi-chemical and mechanical processes. The alkaline sulphite-anthraquinone process is suitable for kenaf bark and whole stems, giving better yield, strength, viscosity and brightness of the pulp than soda and soda-anthraquinone pulping.

Genetic resources Local landraces of vegetable kenaf are presently not at great risk of genetic erosion, but the genetic variability in fibre cultivars is narrow. In Africa no major collections of kenaf have been reported. The Crop Research Institute in Kumasi, Ghana, has a germplasm collection of local cultivars of the vegetable type. In other countries (India, Bangladesh) large collections of kenaf as fibre crop are maintained. The Bangladesh Jute Research Institute (BJRI) at Dhaka, Bangladesh, has been designated as the world germplasm depository for kenaf and maintains a collection of some 920 accessions, including old and new cultivars, landraces, wild and semiwild accessions of kenaf and related species.

Breeding Almost no research has been carried out to enhance the genetic potential. The existing landraces are mixtures of genotypes; the available diversity should be studied and selections made from the desirable types. Purple-flowered strains and the purple false roselle (*Hibiscus acetosella*) are resistant to the main disease of kenaf, root-knot nematodes; hence they are potential sources of desirable genes in breeding programmes.

Breeding of fibre cultivars with high potential yields under suboptimal conditions is urgent as kenaf grown for fibre is being pushed increasingly towards marginal environments. Other breeding objectives are plants without prickly stems and bristly capsules to facilitate harvesting, and resistance to diseases, nematodes and pests.

Prospects Kenaf is a high-yielding and increasingly popular vegetable for the city markets. Contrary to the popular roselle (*Hibiscus sabdariffa*), it can be grown near the equator. At present its main constraint is its sensitivity to nematodes. If this problem can be solved, vegetable kenaf may well face a bright future.

Kenaf fibre is a biodegradable and environment-friendly raw material suitable for many applications, such as woven and non-woven fabrics, geotextiles and semi-rigid and laminated sheets for packaging and panelling. Kenaf stems are an excellent substitute for softwood as raw material for the pulp and paper industry. Prospects for increased kenaf fibre and pulp production are good in view of growing concerns about environmental pollution and dwindling forest resources.

Major references Blundell, 1987; Burkill, 1997; Dempsey, 1975; Edmonds, 1991; FAO, 2011; Leung, Busson & Jardin, 1968; Ravagnan, 2001; Schippers, 2000; Shamsuddin Ahmad & van der Vossen, 2003a; Wilson, 1999.

Other references Akpan, 2000; Amankwatia, 1981; Andrews, 1952; Angelini et al., 1998; Banuelos, 1996; Biagiotti, Puglia & Kenny, 2004; Carberry & Abrecht, 1990; Cook & Mullin, 1994; Crane, Acuna & Alanso, 1946; Eldin & Amin, 1981; Foti, Garnaccia & Patane, 1998; Franck (Editor), 2005; Gutteridge, 1988; Lind & Tallantire, 1975; Mwaikambo, 2006; Peeler, 1967; Peters, O'Brien & Drummond, 1992; Pill, Tilmon & Taylor, 1995; Purseglove, 1968; Vawdrey & Stirling, 1992; Wilson & Menzel, 1964.

Sources of illustration Nabakooza, 2003.

Authors R. Bukenya-Ziraba

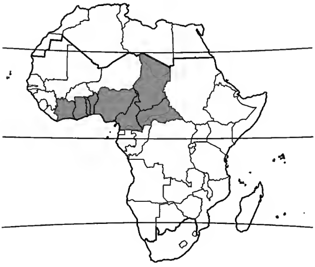
HIBISCUS CONGESTIFLORUS Hochr.

Protologue Annuaire Conserv. Jard. Bot. Genève 10: 21 (1906).

Family Malvaceae

Origin and geographic distribution *Hibiscus congestiflorus* is distributed from Côte d'Ivoire eastward to the Central African Republic.

Uses In Nigeria fibre is extracted from the stem bark. In Côte d'Ivoire the leaves are sometimes used as a vegetable and prepared in sauce, but this use is restricted to periods of shortage of other vegetables.



Hibiscus congestiflorus – wild

Properties The nutritional composition of edible leaves from Côte d'Ivoire was per 100 g: water 76.8 g, energy 170 kJ (41 kcal), protein 6.4 g, fat 0.9 g, carbohydrate 1.6 g, dietary fibre 11.4 g, riboflavin 0.23 mg and ascorbic acid 33.8 mg. The mucilage content of the leaves is 5.7%.

Botany Annual erect herb up to 3 m tall, often unbranched; stem pilose. Leaves alternate, simple; blade linear-lanceolate, up to 18 cm × 4 cm, often hastate at the base, margin serrulate, lower surface slightly pubescent. Flowers crowded at the apex of the shoots, regular, bisexual, 5-merous, 4–6.5 cm long; pedicel very short; epicalyx bracts linear, about as long as the calyx, ciliate; petals yellow with purple centre; stamens numerous, united for most of their length into a staminal column; ovary superior. Fruit a dry capsule, splitting along the midribs. Seeds kidney-shaped.

In West Africa flowering and fruiting of *Hibiscus congestiflorus* usually occur in October–February.

Hibiscus comprises c. 200 species distributed mainly in the tropics and subtropics; many of them are grown as ornamentals. The bark fibre of several other West African *Hibiscus* species is used. *Hibiscus comoensis* A.Chev. ex Hutch. & Dalz. is a poorly known ruderal shrub or small tree, restricted to Guinea, Liberia, Côte d'Ivoire and Ghana. In Côte d'Ivoire its bark is used for tying in hut construction. *Hibiscus owariensis* P.Beauv. is a shrubby species up to 3 m tall distributed from Côte d'Ivoire to Nigeria, with odd records from Rwanda and Sudan. Its bark fibre is of poor quality but is used in Ghana. *Hibiscus scotellii* Baker f. is an erect fibrous herb up to 2 m tall, distributed in Sierra Leone, Liberia, Côte d'Ivoire, Mali, Burkina Faso and Ghana. In Sierra Leone its bark fibre is used for making rope. *Hibiscus squamosus* Hochr. is an annual herb c. 1 m tall, distributed from Senegal eastward to Chad and the Central African Republic. It yields a bark fibre of good quality that is used in Ghana. In Togo leaves collected from the wild are eaten cooked as a vegetable. *Hibiscus sterculiifolius* (Guill. & Perr.) Steud. (synonym: *Hibiscus quinquelobus* G.Don) is a shrub or small tree up to 2.5 m tall, distributed from Senegal to Nigeria, but far from common. Its fibre is locally used for making cordage, thread, sacks and fishing lines and nets. In Côte d'Ivoire its bark is used for tying in hut construction and basketry. Early in the 20th century wild stands have been exploited in Guinea and small quantities of fibre have been exported. Trees can be lopped and the resulting suckers produce the best quality fibre. The wood is fairly hard and can be used to make furniture.

Ecology *Hibiscus congestiflorus* usually occurs in savanna, grassland, gallery forest and fallows, up to 800 m altitude.

Management In Côte d'Ivoire *Hibiscus congestiflorus* is spared during land clearing.

Genetic resources and breeding Little is known about the conservation status of the species.

Prospects The limited amount of available information on *Hibiscus congestiflorus* limits assessment of its prospects. Further ethnobotanical investigations particularly on the use as vegetable in the distribution area might be worthwhile. Several other West African *Hibiscus* species have potential as fibre producers.

Major references Akoègninou, van der Burg & van der Maesen, 2006; Burkill, 1997; Herzog, Gautier-Béguin & Müller, 1996; Keay, 1958d.

Other references Batawila et al., 2007; Gautier-Béguin, 1992; Herzog, 1992; Herzog, Farah & Amado, 1993; Kirby, 1963; Medina, 1959; Tra Bi, 1997.

Authors E.G. Achigan-Dako

HIBISCUS DIVERSIFOLIUS Jacq.

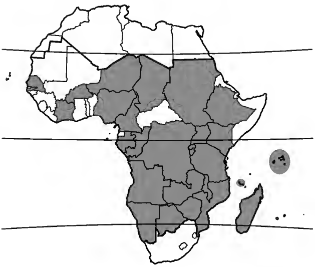
Protologue Collectanea 2: 307 (1789).

Family Malvaceae

Chromosome number $2n = 144$ (180)

Vernacular names Prickly tree hibiscus (En). Sambi (Sw).

Origin and geographic distribution *Hibiscus diversifolius* is widespread in the tropical African continent at higher altitudes. In Madagascar it occurs wild, while in Mauritius it has been introduced and has become naturalized. It also occurs in South Africa, Australia, the Pacific and South and Central America.



Hibiscus diversifolius – wild

Uses The bark fibre is used for making ropes and sewing mats. In Madagascar the bark is used for tying and bark fibres are made into ropes and tissue. The leaves are eaten in south Tanzania and Malawi as a vegetable mixed with beans and/or groundnuts. In Malawi the petals are eaten in a similar way. Woody parts have been used as fire sticks in Malawi. *Hibiscus diversifolius* is planted in hedges around fields in Tanzania and Madagascar.

In traditional medicine in West Africa the pounded leaf is applied to insect stings to ease the pain. In Burundi the sap from leafy twigs is taken as a cure for yaws. In Kenya the stem bark is used for the treatment of malaria and the leaf is chewed to control vomiting. In southern Africa a decoction of the roots and flowers is taken as a cure for pneumonia. In Madagascar a leaf decoction is given as a cure for bronchitis and chronic coughing, especially to children. In traditional veterinary medicine in South Africa the roots are crushed and boiled in water and given to drink to cattle to cure heartwater, helminthiasis and retained-placenta.

Properties Fibre from Uganda investigated in the 1930s contained 72.6% cellulose and 9.1% lignin. The leaves taste bitter or sour and are only eaten during the dry season when other vegetables are scarce.

Botany Scrambling perennial herb, shrub or small tree up to 10 m tall; stem and branches stellate-hairy and often with short prickles. Leaves alternate, simple; stipules linear to filiform, 3–10 mm long, with stiff hairs or bristles; petiole 2–12 cm long; blade 2–12(–18) cm × 5–16 cm, distinctly palmatilobate or palmatipartite with 3–7 lobes, base truncate to cordate, apex acute to rounded, margins irregularly serrate, both surfaces with stellate hairs, lower surface with a deep, narrow slit or a gland near the base of the midrib. Flowers axillary, solitary or sometimes in a terminal raceme, bisexual, 5-merous; pedicel 5–7 mm long, articulated near the base; epicalyx of 7–8(–12) linear segments 6–15 mm long, not forked at the tip, persistent; calyx with lanceolate lobes 2–3 cm long, bristly with a prominent nectary gland on each midrib; petals free, usually spreading, 3–6 cm long, outer side stellate-pubescent, yellow, reddish or purplish with dark red or purple inner base; stamens numerous, filaments united into a column 1.5–3 cm long surrounding the style; ovary superior, ovoid, 5-celled, style branching into 3–5 hairy arms 2–4 mm long, each branch ending in a capitate stigma. Fruit an ovoid, beaked capsule, 1–2 cm × 1–1.5 cm, densely setose. Seeds kidney-shaped, c. 4 mm × 2–3 mm, brown, glabrous. Seedling with epigeal germination.

In Tanzania flowering takes place in June–July. In southern Africa flowering is in July–October, and fruiting in August–December.

Hibiscus comprises c. 200 species, distributed mainly in the tropics and subtropics, with many of them grown as ornamentals. *Hibiscus diversifolius* resembles kenaf (*Hibiscus cannabinus* L.), but has a more shrubby habit. *Hibiscus perrieri* Hochr. is a shrub up to 4 m tall endemic to Madagascar. It yields a strong fibre which is made into rope used for pulling heavy loads.

Ecology In tropical Africa *Hibiscus diversifolius* occurs from sea-level up to 2200 m altitude in damp places along the margins of rivers and lakes, gallery forest, savanna, thickets and cultivated land.

Management *Hibiscus diversifolius* is mostly collected from the wild, but in Tanzania sometimes cultivated and protected in homegardens. In Rwanda in the 1950s stems from wild plants yielded 3.1% fibre after 5 days retting. Defoliated stems of cultivated plants yielded 5.2% fibre after retting for 7 days. The fibre yield of cultivated plants was 600 kg/ha.

Genetic resources and breeding In view of its widespread distribution in tropical Africa and elsewhere, *Hibiscus diversifolius* is not threatened with genetic erosion. In 1969 and 1975 USDA organised trips to Kenya and Tanzania to collect germplasm of wild kenaf and related *Hibiscus* species. Germplasm of *Hibiscus diversifolius* is maintained in the United States. Through interspecific hybridization anthracnose resistance has been transferred from *Hibiscus diversifolius* to kenaf.

Prospects *Hibiscus diversifolius* is less suitable than kenaf for both fibre and vegetable production, but it can play an important role as a genitor, especially for pest and disease resistance.

Major references Burkill, 1997; Lejeune, 1953; Neuwinger, 2000; Ruffo, Birnie & Tengnäs, 2002; Verdcourt & Mwachala, 2009.

Other references Boiteau, Boiteau & Allorge-Boiteau, 1999; Coates Palgrave, 1983; Decary, 1946; Hauman & Wouters, 1963; Hochreutiner, 1955; Masika & Afolayan, 2003; Medley & Kalibo, 2007; Ngari et al., 2010; Norman, 1937; Williamson, 1955; Wilson, 1978.

Authors C.H. Bosch

HIBISCUS MICRANTHUS L.f.

Protologue Suppl. Pl. 308 (1782).

Family Malvaceae

Chromosome number $2n = 64$

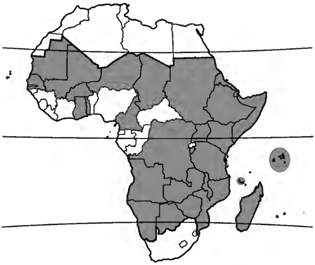
Vernacular names Mchachando, mchunga ng'ombe, mlasa, msase, mtapatapa, muambe (Sw).

Origin and geographic distribution *Hibiscus micranthus* is distributed from Africa eastward to India. In tropical Africa it occurs from Mauritania and Senegal eastward to Eritrea, Ethiopia and Somalia, and from there southward to South Africa and Madagascar.

Uses In Togo the bark fibre is spun into fishing lines. The stems are made into baskets in Uganda and into brooms in Ghana and Tanzania. The Rendille of Kenya use the bark for making containers.

In Tanzania the leaves are eaten as a vegetable and the twigs are used, either peeled or unpeeled, as chewing sticks. The plant is recorded to be browsed by livestock in Kenya and Uganda, whereas in Burkina Faso the foliage is recorded not to be eaten by stock. Children in Uganda eat the ripe seeds.

In traditional medicine the roots are chewed or taken pounded as a cure for cough. In Sudan the roots are used to cure venereal diseases. In Ethiopia, Kenya and Tanzania root preparations are applied as dressings on wounds and sores of humans and domestic animals. In



Hibiscus micranthus – wild

Kenya the ash of burned roots is applied to boils. In Kenya and Tanzania roots preparations are taken to cure bronchitis and pneumonia. In Tanzania the leaves are used for treating earache, the leaf sap is taken against dysentery, water in which leaves have been pounded is taken against stomach-ache, and leaf pulp is applied on swellings. In Botswana pounded leaves are applied to boils on the buttock, or the root is boiled in water that is drunk as a cure. The latter treatment is also used in Kenya by the Embu and the Meru as a cure for ulcers. The leaf sap is used as an antidote for snakebites and as a treatment for kidney problems and stomach-ache. In Tanzania and Zambia the whole plant is used to treat fever, especially convulsive fever in children. The plant is used as a febrifuge in the traditional medicine of Saudi Arabia, India and Sri Lanka. In India a root paste is applied to the skull to cure head ache.

Properties The seed contains 15.2% oil (dry weight basis). Fatty acids present in the seed oil include: palmitic acid 18.6%, stearic acid 3.5%, oleic acid 10.1% and linoleic acid 59.8%. The oil also contains malvalic acid (1.7%) and sterculic acid (3.1%), which are cyclopropenoid fatty acids known to cause physiological disorders in animals.
The methanol extract of the bark of twigs inhibited growth of *Actinomyces viscosus* and the extract of the wood of twigs inhibited growth of *Streptococcus mutans*, which justifies their use as chewing sticks.

Botany Perennial herb or shrub up to 3 m tall; stem erect, longitudinally ridged with age, usually with stiff, rarely with soft, stellate hairs. Leaves alternate, simple; stipules filiform, 2–6 mm long, stiff hairy; petiole 1–23 mm long; blade ovate, elliptical or lanceolate, up to 3.5(–6) cm × 2.5(–5) cm, base cuneate, rounded or truncate, apex acute, obtuse or rounded, margin serrate, both sides sparsely to densely soft-hairy. Flowers axillary, solitary, bisexual, 5-merous; pedicel 3–40(–55) mm long, articulated in upper half; epicalyx of 5–8 subulate, linear or lanceolate segments 1.5–6(–7) mm long, persistent; calyx lobes lanceolate or triangular, 2.5–4.5 mm long, fused in lower half (up to 3.5 mm in some cultivars), persistent, green, densely stiff-hairy; petals free, 5–9(–12) mm long, outside stiff stellate-hairy, white to pink; stamens numerous, filaments united into a column 1.5–5 mm long surrounding the style; ovary superior. Fruit a round capsule 5–10 mm in diameter, sparsely pubescent. Seeds reniform, 2–3 mm × 1.5–2 mm, black. Seedling with epigeal germination.
Over its enormous range of distribution, and even within a country like Ethiopia, the variation in characteristics of *Hibiscus micranthus* is huge. The only consistent characteristic is the small size of flowers and fruits. As the variation is otherwise largely continuous, it makes subdivision in subspecies or varieties meaningless.
Hibiscus comprises c. 200 species, mainly in the tropics and subtropics; many of them grown as ornamentals.

Ecology *Hibiscus micranthus* occurs from sea-level up to 2100 m altitude in grassland and bushland on many different soil types. It is often found in waste places and as a weed of cultivation.

Management *Hibiscus micranthus* is only collected from the wild. The 1000-seed weight is c. 4 g. Seeds store very well for long periods. Seeds stored in the United States for 40 years at –12°C had a germination percentage of 100%.

Genetic resources and breeding Collections of *Hibiscus micranthus* in genebanks are few and the wide variation within the species is poorly understood and certainly not covered by the existing collections. As the species is widespread and not heavily exploited, there is no threat whatsoever of genetic erosion.

Prospects *Hibiscus micranthus* will continue to be used locally for its fibre and as a source of traditional medicine. Research into its medicinal properties is strongly recommended.

Major references Burkill, 1997; Ruffo, Birnie & Tengnäs, 2002; SEPASAL, 2011g; Verdcourt & Mwachala, 2009; Vollesen, 1995a.

Other references Al-Yahya et al., 1987; Heine & Heine, 1988b; Ichikawa, 1987; Jansen, 1981; Kareru et al., 2007; Khan, Ngasappa & Matee, 2000; Neuwinger, 2000; Newmark, 2001; Sundar Rao & Lakshminarayana, 1985; Walters, Wheeler & Grotenhuis, 2005.

Authors C.H. Bosch

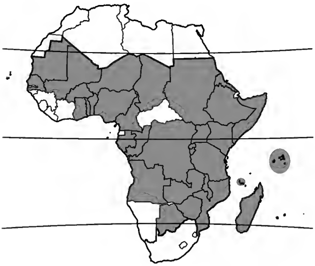
HIBISCUS PANDURIFORMIS Burm.f.

Protologue Fl. Ind. 151, t. 47 f. 2 (1768).

Family Malvaceae

Chromosome number $2n = 24$

Origin and geographic distribution *Hibiscus panduriformis* is widespread in mainland tropical Africa and Madagascar. It also occurs



Hibiscus panduriformis – wild

in Asia and Australia.

Uses In DR Congo and Tanzania the bast fibre is used for cordage. In Kenya it is used for weaving bags. The flowers are eaten in DR Congo. *Hibiscus panduriformis* is sometimes grown as an ornamental.

Properties The bast fibre of *Hibiscus panduriformis* is creamy white, soft and fairly lustrous, it is not very durable and is considered of poor quality. The fibre cells are 0.8–2.7 mm long and 14–29 μm in diameter, with an average cell wall thickness of 5.7 μm.

The seeds contain per 100 g dry matter: oil 15.4 g, protein 22.2 g, crude fibre 27.3 g. Fatty acids in the seed oil are: palmitic acid 12.3%, stearic acid 3.2%, oleic acid 10.2% and linoleic acid 74.3%. The oil is pale yellow.

Botany Erect perennial herb or shrub up to 4 m tall, branched at the top; stem tomentose and with long simple or branched irritating hairs up to 5 mm long, becoming glabrous. Leaves alternate, simple; stipules often 2–3 side by side, filiform, 5–12 mm long; petiole 2–18 cm long, densely hairy; blade linear to ovate or orbicular in outline, 4–18 cm × 3–14 cm, unlobed to shallowly 3–7-lobed, base cordate to truncate, apex obtuse to acute, margin toothed, both sides hairy, conspicuously 5–7-veined. Flowers 1–4 in leaf axils, regular, bisexual, 5-merous, 3.5–10 cm in diameter; pedicel 3–30 mm long, articulated near the middle, densely hairy; epicalyx bracts 8–12, linear-spathulate, 5–17 mm × 1–2 mm, pubescent; calyx 10–20 mm long, lobes linear to triangular, 11–13 mm × 2–6 mm, densely puberulous to tomentellous, conspicuously 3-veined or 3-ribbed; petals 15–50 mm long, pale yellow to yellow with maroon centre, densely hairy outside; stamens numerous, united for most of their length into a staminal column 8–20 mm long, free parts of filaments 0.5–3 mm long; ovary superior, style 10–15 mm longer than staminal column, with branches 30–50 mm long. Fruit an ovoid to subglobose capsule 10–18 mm × 8–15 mm, on a stalk c. 55 mm long, acuminate, densely hairy, coriaceous at maturity. Seeds wedge-shaped, c. 3 mm × 2 mm, brown, striped, hairy.

In West Africa flowering and fruiting usually take place in June–December; in Zimbabwe and Mozambique flowering is in March–May.

Hibiscus comprises c. 200 species, distributed mainly in the tropics and subtropics, and many of them are grown as ornamentals. *Hibiscus debeerstii* De Wild. & T.Durand and *Hibiscus shirensis* Sprague & Hutch. are perennial herbs or shrubs very similar in morphology, ecology and distribution. They differ from one another in the relative size of the epicalyx that in the former species is larger than the calyx and in the latter smaller. Both species are distributed in DR Congo, Tanzania, Malawi, Zambia and Mozambique. *Hibiscus shirensis* is also native to Rwanda, Burundi and Zimbabwe. The bast fibres of both species are used for making ropes. In Mozambique the shrubs are browsed by livestock.

Anatomy In a transverse section of *Hibiscus panduriformis* stems harvested at the first pod stage in India the bast fibres occurred in wedges. The number of fibre bundles per wedge was c. 22, with c. 19 cells per bundle. The fibre bundles were irregularly shaped.

Ecology *Hibiscus panduriformis* occurs from sea-level up to 2000 m altitude in woodland and grassland, alluvial clay flats, riverbanks, roadsides, cultivated land and fallows.

Management The 1000-seed weight is 5.3–5.7 g. The fibre yield per plant is low. The presence of the plant near cultivated cotton can be troublesome as both plants are attacked by bollworms (*Earias* spp.).

Genetic resources and breeding In view of its wide distribution in tropical Africa and elsewhere, *Hibiscus panduriformis* is not threatened with genetic erosion.

Prospects *Hibiscus panduriformis* will probably remain of local importance for fibre purposes. Further ethnobotanical study might be worthwhile given the wide distribution of the species in tropical Africa and the scarce information on its use.

Major references Burkill, 1997; Kittur et al., 1982; Maiti, 1979; Maiti, 1997; Verdcourt &

Mwachala, 2009.

Other references Akoègninou, van der Burg & van der Maesen, 2006; Dhankhar & Mishra, 2004; Exell & Meeuse, 1961; Fryxell & Stelly, 1993; Hauman & Wouters, 1963; Keay, 1958d; SEPASAL, 2010g; Stefanesco & Bintoni-Juliassi, 1982; Thulin, 1999a; Vollesen, 1995a.

Authors E.G. Achigan-Dako

HIBISCUS SABDARIFFA L.

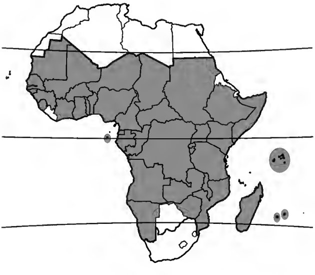
Protologue Sp. pl. 2: 695 (1753).

Family Malvaceae

Chromosome number $2n = 72$

Vernacular names Roselle, Jamaican sorrel, Indian sorrel, bissap, karkadeh (En). Roselle, oseille de Guinée, karkadé, bissap, thé rose d'Abyssinie, groseille pays (Fr). Vinagreira, azeda de Guiné, azedinha, caruru azedo, quiabeiro azedo (Po). Ufuta, ufuta dume (Sw).

Origin and geographic distribution *Hibiscus sabdariffa* probably originates from Africa, where it may have been domesticated in Sudan about 6000 years ago, first for its seed and later for leaf and calyx production. In the 17th century vegetable types were introduced to India and the Americas. Selection for fibre production took place in Asia, where cultivation is reported from the beginning of the 20th century, e.g. in India, Sri Lanka, Thailand, Malaysia and Java. Roselle is now found throughout the tropics. In tropical Africa it is especially common in the savanna region of West and Central Africa. It is often found as an escape from cultivation. However, apparently truly wild plants of *Hibiscus sabdariffa* have been collected in Ghana, Niger, Nigeria and Angola.



Hibiscus sabdariffa – planted

Uses In Africa roselle has two main uses: as a vegetable and for preparation of a beverage. Young roselle shoots, leaves and calices are used as a cooked vegetable or finely cut and used in sauces. The leaves and fresh green calices are used to make a soup, which is rather mucilaginous in texture. Freshly harvested leaves and/or calyces are also added to water-based sauces; oil, salt, onions, dried fish and hot pepper are often added. The sauces are eaten with tuber or cereal porridges or rice. Green roselle types are more appreciated for use as a cooked vegetable than red types, which are more commonly used in sauces. In some areas the leaves are mixed with groundnut or sesame paste. The stewed calyces of the green type are added as a condiment ('bëkëj') to rice dishes in Senegal. In the United States leaves and young shoots are also eaten raw in salads and the red fleshy calyx lobes are chopped and used in fruit salads, but these uses are not common in Africa. In Côte d'Ivoire the dried calyces ground to powder are used in sauces during the dry season.

The dried red calyces are commonly used to prepare a tea, drunk hot or, more commonly, cold after adding sugar. It is a sour tasting, refreshing drink, very popular from Senegal to Sudan and in Egypt and other northern African countries where it is referred to as 'karkadé'. Juice is often sold chilled or frozen as 'bissap' (Senegal) or 'da bilenni' (Côte d'Ivoire, Mali, Burkina Faso) along highways and in urban markets. Mint or ginger is sometimes added when boiling the calyces, particularly if the juice is to be sold frozen. The calyces are also boiled down to make a syrup concentrate. Due to their high inherent pectin content, roselle jams and jellies are also popular, particularly in Senegal, the Caribbean region and southern Asia. The dried calyces are used in Western countries as a base for many herbal teas and as a source of red food colorants. Following calyx harvest in West Africa, roselle plants are often used as fodder for livestock.

The oil of roselle seed is extracted and used for cooking, e.g. in Chad, Tanzania and China. However, the seed oil is claimed to contain some toxic substances and may be better used in the soap and cosmetics industries. Locally, the seeds are eaten roasted as a snack or ground into meal. In the Plateau region of Nigeria people ferment roselle seeds to make a cake used as 'sorrel meat'. The oil is also used as an ingredient of paints.

Roselle tea is used to suppress high blood pressure. The leaves are a source of mucilage used in pharmacy and cosmetics. Extracts are often used medicinally to treat colds, toothache, urinary tract infections and hangovers. Leaf juice is used to treat conjunctivitis in Senegal. Leaves are applied as a poultice to treat sores and ulcers. A root decoction can be used as a laxative.

As in Asia, roselle fibre is locally used in West Africa, but on a very small scale. The bast fibre is a good substitute for jute and it is used for making twine, cordage, rope, netting and sacks. The bast fibre and sometimes also the whole stem are used in the paper industry in the United States and Asia. The woody central core material ('stick') of the stem can also be used for paper making. The ornamental value of roselle is of recent interest, as a garden plant or cut flower. The decorative red stalks with ripe red fruits are exported to Europe where they are used in flower arrangements.

Production and international trade Roselle is an important leafy vegetable in the drier parts of West and Central Africa. In Senegal, Mali, Chad and Sudan large quantities of calyces are produced for the preparation of beverages. Sudan is the major country in tropical Africa producing dried roselle calyces for local consumption and export, mainly in the Kordofan and Darfur regions in the west of the country. Production of roselle leaves and calyces for domestic consumption in Africa has not been quantified, although these are common products on local markets.

International trade of roselle calyces has increased steadily over the last decades, with 15,000 t/year now entering the world market. Germany and the United States are large importers. In 1998, United States and German importers paid US$ 1200–1700/t for Egyptian and Sudanese roselle; prices of Chinese roselle were lower. Prices fluctuate due to high variability in supply. A decrease in product quality in Thailand and China due to excessive precipitation caused world prices to soar to US$ 4000/t in 2003.

Sudan is the most important roselle producer in Africa, the annual area fluctuating between 11,000 ha and 57,000 ha depending on the amount of rainfall and prices. In 1995 Sudan reported exports of 32,000 t. In Sudan smallholder farmers traditionally grow roselle in plots ranging from under 0.25 ha to 2 ha, but some growers have up to 20 ha. Sudanese roselle is viewed as superior quality, but the United States trade embargo and large-scale production in Mexico, Thailand and China has led to shifts in the market. Jamaica and Egypt also export roselle. Senegal and Mali are also major producers, but the vast majority of their production is for domestic consumption or sold on the local markets. Fluctuations in export prices for cash crops such as cotton have led many West African farmers to diversify production, e.g. by growing roselle for the domestic market.

The average annual world production in 2004–2008 of jute-like fibres, a group including, among others, roselle, kenaf (*Hibiscus cannabinus* L.), Congo jute (*Urena lobata* L.), sunn hemp (*Crotalaria juncea* L.) and devil's cotton (*Abroma augusta* (L.) L.f.), was about 350,000 t, harvested from 250,000 ha. Separate statistics of these species are unavailable, but roselle is estimated to make up only a small part of this total.

Properties The nutritional composition of roselle leaves per 100 g edible portion is: water 85.6 g, energy 180 kJ (43 kcal), protein 3.3 g, fat 0.3 g, carbohydrate 9.2 g, dietary fibre 1.6 g, Ca 213 mg, P 93 mg, Fe 4.8 mg, β-carotene 4135 μg, thiamin 0.2 mg, riboflavin 0.45 mg, niacin 1.2 mg, ascorbic acid 54 mg. The composition of fresh raw calyces per 100 g edible portion is: water 86.2 g, energy 184 kJ (44 kcal), protein 1.6 g, fat 0.1 g, carbohydrate 11.1 g, fibre 2.5 g, Ca 160 mg, P 60 mg, Fe 3.8 mg, β-carotene 285 μg, thiamin 0.04 mg, riboflavin 0.06 mg, niacin 0.5 mg, ascorbic acid 14 mg. The nutritional composition of the seed per 100 g edible portion is: water 8.2 g, energy 1721 kJ (411 kcal), protein 19.6 g, fat 16.0 g, carbohydrate 51.3 g, dietary fibre 11.0 g, Ca 356 mg, P 462 mg, Fe 4.2 mg, thiamin 0.1 mg, riboflavin 0.15 mg, niacin 1.4 mg, ascorbic acid trace (Leung, Busson & Jardin, 1968).

The dried red calyces contain organic acids, sugars and anthocyanin pigment. They are high in citric, malic and ascorbic acids. Roselle seed oil has properties similar to cotton seed oil and contains linoleic, oleic, palmitic and stearic acids as major fatty acids. A number of exceptional fatty acids, e.g. epoxy oleic acid and the cyclopropene acids sterculic acid and malvalic acid, have been reported in the seed oil. Seed proteins are mostly globulins, highly soluble at acidic and alkaline pH levels.

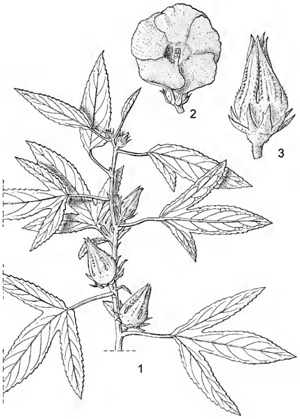
Roselle has antispasmodic, anthelminthic and bactericidal properties. The antihypertensive and cardioprotective effects of tea made from roselle calyces have been demonstrated in various animal tests, and also in a few clinical tests. The phenolic compound protocatechuic acid isolated from roselle flowers showed antioxidant, antitumour and hepatoprotective activities. Roselle extracts also showed antipyretic and anodyne properties in tests with mice. The seed oil exhibits antibacterial and antifungal activities.

Roselle produces a bast fibre similar to jute (*Corchorus* spp.), except that it is whiter and somewhat coarser. The raw retted and dried fibre makes up about 5% and the dry wood 18% of the freshly harvested and defoliated green stems. The commercial fibre has a length of up to 2.1 m. The bast fibre cells are (1.2–)1.9–3.1(–6.3) mm long and (10–)12–25(–44) μm wide, with maximum length and width in the middle portion of the stem. Lumen width and cell wall thickness vary from 3–15 μm and (4–)8–15 μm, respectively. Most fibre cells have tapering rounded ends. The wood consists of fibre cells 0.5–1.0 mm long and about 24–26(–32) μm wide, with a lumen width of 9 μm and a cell wall thickness of 3–7 μm. The bast fibres contain about 32% α-cellulose, 10–15% lignin and 1% ash.

The bark, core and whole stems have been pulped using the soda-process, giving yields of 52–54%. The strength properties (breaking length, burst factor and tear factor) were better for bark pulps than for core and whole stem pulps. Cores as well as whole stems have been pulped using the soda-anthraquinone process, giving 47–54% pulp, with whole-stem pulp having better mechanical properties.

Adulterations and substitutes Leaves of other *Hibiscus* spp., e.g. kenaf (*Hibiscus cannabinus*) and false roselle (*Hibiscus acetosella* Welw. ex Hiern) can be used as substitutes for roselle. They are sometimes even sold together.

Description Large annual herb up to 4.5 m tall; stem glabrous to sparsely pubescent, sometimes sparsely prickly, green or reddish. Leaves alternate, simple; stipules narrowly lanceolate to linear, up to 1.5 cm long; petiole 0.5–12 cm long; blade shallowly to deeply palmately 3–5(–7)-lobed, sometimes undivided, up to 15 cm × 15 cm, margin toothed, glabrous or sparsely pubescent, sometimes with a few prickles on midrib, palmately veined, with a distinct nectary at base of midrib. Flowers solitary in leaf axils, bisexual, regular, 5-merous; pedicel up to 2 cm long, articulate; epicalyx segments 8–12, united at base, subulate to triangular, free part 0.5–2 cm long; calyx campanulate, up to 5.5 cm long, becoming fleshy in fruit, lobes nearly glabrous to hispid hairy, with a nectary outside; petals free, obovate, up to 5 cm × 3.5 cm, pale yellow or pale pink, often with dark red-purple centre; stamens numerous, united into a column up to 2 cm long, pink; ovary superior, 5-celled, style with 5 branches. Fruit an ovoid capsule up to 2.5 cm long, almost glabrous to appressed-pubescent, enclosed by the calyx, many-seeded. Seeds reniform, up to 7 mm long, dark brown. Seedling with epigeal germination; cotyledons rounded, up to 2.5 cm × 3 cm, leafy.



Hibiscus sabdariffa – *1, flowering and fruiting shoot; 2, flower; 3, fruit enclosed by calyx.*
Source: PROSEA

Other botanical information *Hibiscus* comprises 200–300 species, mainly in the tropics and subtropics; many of them grown as ornamentals. The estimated number of species varies because opinions differ about inclusion of several related groups of species in the genus. *Hibiscus sabdariffa* belongs to section *Furcaria*, a group of about 100 species which have in common a pergamentaceous calyx (rarely fleshy) with 10 strongly prominent veins, 5 running to the apices of the segments and bearing a nectary, and 5 running to the sinuses. Other species belonging to this section and used as a vegetable are *Hibiscus acetosella*, *Hibiscus asper* Hook.f., *Hibiscus cannabinus*, *Hibiscus diversifolius* Jacq., *Hibiscus mechowii* Garcke, *Hibiscus noldeae* Baker f., *Hibiscus rostellatus* Guill. & Perr. and *Hibiscus surattensis* L.

Two main types of cultivated *Hibiscus sabdariffa* are distinguished, originally described as botanical varieties: var. *sabdariffa* with a bushy, strongly branching habit and glabrescent calyx, accrescent and becoming fleshy in fruit; and var. *altissima* Wester with taller, usually unbranched habit and often hispid hairy calyx, hardly accrescent and not fleshy in fruit. The latter is grown for its fibre, and not common in Africa. These types can best be regarded as cultivar-groups.

Hundreds of cultivars grown as vegetable or for their calyces exist. In some of these anthocyanins are present, resulting in reddish stems, leaves and calyces, and pinkish petals, whereas in others anthocyanins are absent, and these have green stems and leaves, pale green calyces and pale yellow petals.

Growth and development The vegetative growth period lasts from 4 months to 6 months. Plant height 30 days after emergence of the seedlings is about 30 cm. Leaf harvest may start 6–8 weeks after sowing; it stimulates branching and subsequently increases leaf production. Flowering begins when daylength decreases, at the earliest 2 months after sowing, and at the latest 7 months. The flowers are ususally self-pollinating. Two or three months after pollination fruits may begin to ripen.

Ecology Roselle has temperature requirements ranging between 18°C and 35°C. Plant growth stops at 14°C, with death occurring after 15 days. At 10°C, death occurs after only 2–3 days. Flower and calyx production is reduced at temperatures below 17°C. Cotyledons cannot withstand temperatures below 10°C for more than 2–3 hours.

Roselle is a photoperiod sensitive plant that flowers best when the daylength is shorter than 12 hours. It requires 13 hours/day light during vegetative growth to prevent premature flowering. Having a deep root system, roselle requires adequate soil depth and is rather drought resistant. The crop can grow in a wide range of soil types, the best being retentive, friable loams. Roselle thrives in areas receiving 800–1600 mm of continuous annual rainfall, and requires a minimum of 100–150 mm/month during vegetative growth, or 300–400 mm distributed over a period of 3–4 months. Dry periods during the final months of growth promote good calyx production, while excess precipitation or humidity can lower the quality of the calyces. Roselle plants with anthocyanin pigmentation are able to withstand the harsh Sahelian environment better than plants with a yellow-green colour.

Apparently wild types of *Hibiscus sabdariffa* are found in savanna grassland and open woodland.

Propagation and planting Roselle is grown both as a rainfed field crop and as an irrigated garden vegetable. As leafy vegetable, seeds are either broadcast or dibbled with 3–5 seeds/hole, 2–3 cm deep, at an average spacing of 40–60 cm in rows and 60–90 cm between rows. The 1000-seed weight is (15–)25–28 g. For calyx production, the spacing should be wider, up to 100 cm apart. In Senegal vegetable farmers use 15–25 kg seed per ha for calyx production, whereas research recommends only 4–8 kg. Some growers sow in a shaded nursery, and transplant into the field after about 4 weeks. For fibre production, seeds are drilled more closely, at 15 cm × 20 cm or 10 cm × 30 cm. Because roselle is deep rooting, deep ploughing is recommended for heavier soils. In sandy soils shallow ploughing is common.

Rainfed roselle crops are sown at the beginning of the rainy season. In the Sahel region year-round planting is possible with irrigation. Roselle is often intercropped with other crops such as pearl millet, sorghum, groundnut, sweet potato, yam or cowpea, and spontaneous roselle plants are often allowed to grow amongst other crops. Many farmers plant roselle along field boundaries or to delineate subplots within a field. In West Africa roselle is also grown as part of a parkland agroforestry system, in conjunction with e.g. apple-ring acacia (*Faidherbia albida* (Delile) A.Chev.), baobab (*Adansonia digitata* L.), African locust bean (*Parkia biglobosa* (Jacq.) R.Br. ex G.Don, shea butter tree (*Vitellaria paradoxa* C.F.Gaertn.) and jujube (*Zizyphus mauritiana* Lam.).

Management Roselle grown in home gardens as a leafy vegetable or for leaves and calyces is cultivated under irrigation, mostly done manually with watering cans. It is given normal garden management. When grown as a field crop for calyces little care is generally given unless grown in intercropping. It then benefits from the care given to the main crop. Roselle responds well to fertilizers. In Egypt ammonium sulphate has been reported to result in higher yields than calcium nitrate or urea. Calyx production is greater when plants are fertilized at thinning (20–30 days after planting) than when the applications are split and given during the vegetative stage and at flowering. However, chemical fertilizers are rarely applied in tropical Africa as they are too costly under the uncertain climatic conditions where roselle is grown. A few t per ha of dry organic manure is sometimes applied. Smallholder farmers regard roselle as a low-input, low-labour crop. Weeding is rarely practised, but if done it results in higher calyx yields. Better calyx yields were observed when roselle is intercropped, particularly with a legume planted two weeks after establishment of the roselle crop.

In Thailand and India roselle for fibre is grown as a rainfed crop. A single round of weeding and thinning is usually performed 20–30 days after planting. The recommended fertilizer dose is 15 kg N, 15 kg P and 15 kg K per ha given after weeding.

Diseases and pests Roselle is susceptible to most diseases affecting cotton, and root and stem rot caused by several *Phytophthora* spp. lead to plant losses. *Phytophthora nicotianae* var. *parasitica* causes stem burn (also called collar rot or stem canker), causing purplish black discoloration encircling the stem 30 cm above the ground and sudden wilting of the plant. Resistance has been found in fibre-type roselle cultivars. Unlike its close relative kenaf, roselle is susceptible to infection by *Coniella musaiaensis* var. *hibisci*. Plant and calyx senescence due to this pathogen have been observed in Central Africa, Nigeria, the Caribbean region and India. Irregular, pale brown lesions appear on lower leaves increasing in size, bleaching the leaf surface and ultimately resulting in necrosis of tissue. Brown stem lesions may also develop. Leaf spot caused by *Cercospora hibisci* is also common. Roselle types with green leaves are susceptible to powdery mildew (*Oidium abelmoschi*), types with red leaves are partially resistant. A virus disease is reported from Nigeria, causing hard cracking leaves. Roselle is rather resistant to root-knot nematodes (*Meloidogyne* spp.), but not to free-living nematodes (*Heterodera* spp.).

Pressure from insect pests is high. Cotton bollworm larvae (*Earias biplaga*, *Earias insulana*) are very damaging as they bore into the unripe fruits. The larvae of flea beetles (*Podagrica* spp.) feed on the roots and the adults damage leaves and growing points. The cotton stainer (*Dysdercus superstitiosus*) sucks on the calyces, causing brown spots. Infestation by spiral borers (*Agrilus acutus*) can lead to galls on the stems, approximately 5 cm in length and leading to some reduction in nutrient uptake. However, research in Bangladesh has demonstrated roselle to be much more resistant to infestation than kenaf. Other pests are cutworm, mealy bugs, leaf hoppers and snails. Attacks by insect pests can be reduced by beneficial predators, e.g. it was observed that jassids (*Amrasca biguttula*) were predated by 8 species of spiders. Similarly, *Hibiscus sabdariffa* has helped reduce pest populations in intercropped systems, e.g. infestation of bean (*Phaseolus vulgaris* L.) by several white fly species was reduced by intercropping with roselle, due to increased hyperparasite diversity.

Harvesting The first harvest comprises seedlings collected during thinning. When the plants are 6–8 weeks old, branches of about 50 cm long are picked 2 or 3 times during the period of vegetative growth. Calyces are harvested manually 2–3 weeks after flowering, usually 4–6 months after sowing, before the fruit has dried and dehisced. Regular picking prolongs flowering. The calyces are dried in the shade. When harvested for fibre, stems are cut before flowering, 4–5 months after planting. Fibre quality declines rapidly after the start of flowering.

Yield For leafy branches yields of up to 20 t/ha from three cuttings have been reported. Fresh calyx yields range from 4–6.5 t/ha, or about 800–1200 kg/ha when dried to 12% moisture content. In Asia fresh calyx yields of up to 15 t/ha have been reported. A single roselle plant may yield as many as 250 calyces, or 1–1.5 kg fresh weight. In Africa average yields are much lower and variable because of environmental conditions and extensive management. Sudan reports an average yield of dry calyces of 93 kg/ha. In Senegal maximum production of calyx on a dry weight basis is 500 kg/ha.

Average fibre yields from roselle are 1.5–2.5 t/ha, depending on cultivar and management. India reported an average yield of 1.9 t/ha for 1997–2001. Reported seed yields range from 200–1500 kg/ha.

Handling after harvest As a leafy vegetable roselle shoots are sold in bunches with a length of up to 50 cm. Thinned seedlings are less perishable than shoots; as they are sold with their roots attached they can be kept fresh by placing the roots in water.

In most areas in Africa roselle calyces are air dried prior to marketing. Drying in the sun can lead to reduced quality. Adequate ventilation is important. Plastic sheets are placed on the ground to avoid contamination with soil, which also strongly reduces the value. Drying by artificial heating is capital-intensive and rare in sub-Saharan Africa. Temperatures must remain below 43°C.

Dried calyces are gathered and sold in bulk or in individual sachets throughout West Africa. In Senegal dried calyces are rolled into 80 kg balls for export. Roselle exported to the United States and Germany must meet strict standards concerning moisture content (maximum 12%), acidity, residues and contaminations.

To make roselle syrup, dried calyces are boiled at a ratio of 1 part dried roselle to 4–5 parts water. Because of its very tart taste, large amounts of sugar are added. The mixture is boiled down for several hours. Before use the syrup is watered down to make 'da bilenni'. A study estimated that one person could produce about 300 l juice per day from 4 kg calyces.

For the production of fibre, harvested stems are soaked in water for two weeks, and then stripped of bark. Stems are then beaten to separate the fibres, which are washed, dried, and sorted into one of three levels of quality, based on length, colour, stiffness and purity. In some parts of Africa roselle seeds are ground into meal for addition to cereals, or seeds are roasted and boiled as a coffee substitute. Oil is extracted by parching the seeds, soaking in water made alkaline with ashes, and pounding them. The residue is sometimes eaten in soup or blended with bean meal to make fried snacks.

Genetic resources Local cultivars of roselle are common throughout semi-arid Africa. Although many smallholder farmers separate seeds by cultivar, stocks are generally heterogeneous. Roselle planted by traditional farmers in Sudan is usually of several different types and cultivars. Around 50 accessions from the local genetic resources in Sudan are preserved in the genebank of the Plant Genetic Resources Unit of the Agricultural Research Corporation, Wad Medani, Sudan. Characterization of some of these accessions revealed variation in stem colour, leaf shape and calyx shape, colour and size. A practical classification used in Sudan for the many beverage strains is on the basis of calyx characteristics. The calyx lobes may be thick, curved outwards and easy to peel; or long, bending inwards, enclosing the fruit and easy to peel; or thin, tightly enclosing the fruit and difficult to peel; or bell shaped with well-developed epicalyx. In Senegal farmers distinguish between 7 'bissap' types, 3 green types and 4 red ones. The distinctive characters used to identify the 'bissap' types include colour, size and shape of leaves and fruits. Seeds of 'bissap' germplasm in Senegal are stored at the Seed Production Unit, Horticultural Development Centre (CDH), Dakar. Other germplasm collections of *Hibiscus sabdariffa* are held at Jute Research Institute, Dhaka, Bangladesh (320 accessions), USDA Southern Regional Plant Introduction Station, Griffin GA, United States (95 accessions), Central Research Institute for Jute and Allied Fibres, Barrackpore, India (75 accessions) and National Horticultural Research Institute, Ibadan, Nigeria (11 accessions).

Breeding Roselle breeding has hitherto received little attention. The Sudanese cultivar 'El Rahad' is considered superior in quality for calyx production. Breeding objectives of roselle in Sudan include purification of local cultivars and selection for better yield and calyx quality. In Senegal the objectives of the breeding programme include the improvement of leaf yield of green cultivars, and the improvement of yield and taste of cultivars suited for calyx production. Seed company Technisem markets seed of cultivar 'Bissap Koor Rouge', suitable for use as leafy vegetable and for calyx production, and tolerant of nematodes and heat.

Prospects Roselle is an underutilized multipurpose crop providing farmers with food and cash income when other vegetables have become scarce. Processing generates additional family income, from which women benefit in particular. Use of roselle as a vegetable or as a beverage should be promoted through research to improve cultivars, husbandry and post-harvest technologies. Applying rigorous quality standards for grading, processing and packaging will boost competitiveness in the international market. Demand for roselle fibre is likely to increase as a result of the rising interest in natural, biodegradable fibres.

Major references Boonkerd, Na Songkhla & Thephuttee, 1993; Dupriez & De Leener, 1987; FAO, 1988; FAO-AGSI, 1999; Morton & Dowling, 1987; Schippers, 2002; Seck, Sow & Niass, 1999; Shamsuddin Ahmad & van der Vossen, 2003b; Undang A. Dasuki, 2001; van Epenhuijsen, 1974.

Other references Adamson & Monton, 1982; Ahmad & Faruquzzaman, 2000; Akindahunsi & Olallleye, 2003; Babatunde, 2003; Diouf et al., 1999; El-Adawy & Khalil, 1994; El-Gamal,

Omar & Mahmoud, 1997; FAO, 2011; Katende, Ssegawa & Birnie, 1999; Lakshminarayana et al., 1980; Leung, Busson & Jardin, 1968; McCaleb, 2000; Nishimura, Izumi & Kuroda, 2002; Persad & Fortune, 1989; Rao et al., 1980; Sarojini et al., 1985; Stevels, 1990; Thakur, Pandotra & Sastry, 1977; Wilson, 1999; Wolfson, Marani & Steinitz, 1987.

Sources of illustration Boonkerd, Na Songkhla & Thephuttee, 1993.

Authors N.C. McClintock & I.M. El Tahir

HIBISCUS TILIACEUS L.

Protologue Sp. pl. 2: 694 (1753).

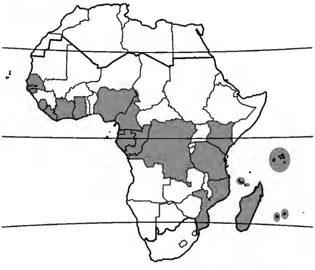
Family Malvaceae

Chromosome number $2n = 80, 96$

Vernacular names Beach hibiscus, bladder ketmia, cotton tree, cottonwood, Hawaiian tree hibiscus, lagoon hibiscus, linden hibiscus, sea hibiscus, tree hibiscus, wild cotton tree (En). Bois de liège, liège des Antilles, purau (Fr). Algodão da praia, uacima da praia (Po). Mtakawa (Sw).

Origin and geographic distribution *Hibiscus tiliaceus* is distributed in coastal areas throughout the tropics of Africa, America, Asia, Australia and the Pacific Islands.

Uses The bark fibre of *Hibiscus tiliaceus* is widely used for making cordage and fishing lines and nets. In DR Congo fine stems are woven into mats. In Madagascar the fibre is also used for textiles and the bark for making bark cloth. In South-East Asia the bark fibre is used for making good quality ropes also used for caulking boats, and the leaves are used for wrapping food.



Hibiscus tiliaceus – wild and planted

The wood is mainly suitable for light construction and cabinet work. It is also used for tool handles, and has been applied for ship and boat building (frames and keels). It is suitable for the manufacture of plywood, hardboard and paper and is used as fuelwood. In Gabon it is made into floats. *Hibiscus tiliaceus* is used in living fences and windbreaks, as a shade tree and as a support for climbing crops. It is widely planted to reforest eroded land, especially along seashores. Various pink- and white-flowered and purple-leaved varieties are widely planted as ornamentals.

In Gabon the leaf is credited with emollient properties. In Tanzania a root decoction is drunk as a tonic and as a cure for hypertension, sickle cell anaemia and irregular menstruation. In Madagascar an infusion of the flowers is drunk to solve respiratory problems.

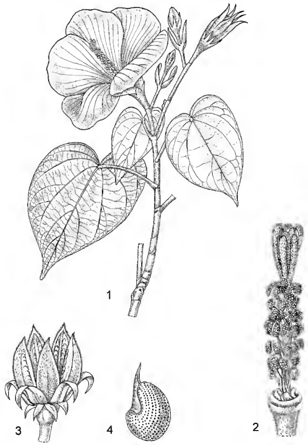
Properties The bark fibre is similar in quality to that of jute and it becomes stronger after being soaked in water. Paper made from *Hibiscus tiliaceus* pulp is of low quality as the fibres are short (0.7–1.3 mm). The rough surface of the underside of the leaves permits the attachment of fungal mycelia and is ideal for promoting homogeneous fermentation of products such as 'tempeh' (made of soybean).

The wood has a density of about 550 kg/m^3 at 12% moisture content. The rates of shrinkage from green to 12% moisture content are low: 1.2% radial and 2.8% tangential.

The seed contains 2.2% oil. The oil contains malvalic acid and sterculic acid, which are cyclopropenoid fatty acids known to cause physiological disorders in animals.

Hibiscus tiliaceus contains sesquiterpenoid quinones and lapachol. The anthers contain gossypetin glucosides with antibacterial activity, gossypitrin and gossytrin. An acetone extract of the leaves showed antibacterial activity against *Staphylococcus aureus*. Antioxidant activities have been reported for aqueous extracts of the flowers.

Description Shrub or small tree up to 15 m tall; stem and branches glabrous to densely stellate-pubescent, becoming brown-grey with lenticels. Leaves alternate, simple; stipules lanceolate to narrowly ovate, up to 3.5 cm long, early falling; petiole 6–15(–17) cm long; blade ovate to orbicular, unlobed or rarely 3-lobed, 3–22 cm × 3–23 cm, base cordate, apex acuminate or rounded, margin entire or finely toothed, upper surface glabrous or sparsely stellate-pubescent, lower surface glabrous or sparsely stellate-tomentose, 5–9-veined from the base,



Hibiscus tiliaceus – 1, flowering twig; 2, stamens and styles; 3, fruit; 4, seed.
Source: PROSEA

the principal veins with a nectary near the base below. Flowers in terminal 3–6-flowered cymes, bisexual, regular, 5-merous; pedicel 0.5–2 cm long, articulated at base; epicalyx cup-shaped, with 10 teeth up to 5 mm long; calyx lobes lanceolate, up to 18 mm long, fused at base for 1/3 of their length, with prominent gland on each lobe; petals free, obovate, 4–7 cm × 1–2 cm, yellow with dark red base; stamens numerous, united into a column up to 2.5 cm long; ovary superior, 5-celled, style with 5 branches. Fruit an ovoid to ellipsoid capsule up to 3 cm long, densely soft grey-hairy, many-seeded. Seeds reniform, c. 4 mm × 2 mm, brown. Seedling with epigeal germination; cotyledons rounded.

Other botanical information *Hibiscus* comprises c. 200 species, mainly in the tropics and subtropics; many of them grown as ornamentals. *Hibiscus tiliaceus* is closer to *Azanza* and *Thespesia* genera than to other members of the genus *Hibiscus*, which may lead to its separation from *Hibiscus*. The species is very polymorphic and has been divided into 7 subspecies, differing by the size of the epicalyx, the form and hairiness of the leaves, and the hairiness of the seeds. *Hibiscus tiliaceus* subsp. *elatus* (Hochr.) Borss.Waalk. (stout habit and large flowers) is the subspecies native to the coastal regions of West Africa and eastern tropical America.

Growth and development *Hibiscus tiliaceus* is a short-day plant. It is fast-growing and plants from cuttings flower and produce seeds after 270–365 days, while those from seedlings bear their first mature fruits at about 2–3 years. In southern Africa flowering is in September–February, and fruiting in September–March. Flowers are pollinated by insects and birds. The fruits ripen 5–7 weeks after pollination. The seeds can float in sea water for several months and are commonly found along shores.

The plant has a widely spreading, superficial root system. Association of the roots with myccorhiza has been confirmed in a number of cases with a significant effect on production of inoculated plants. Root nodules have been observed in the Solomon Islands, where it is purposely planted for soil restoration, but atmospheric nitrogen fixation has not been confirmed.

Ecology *Hibiscus tiliaceus* occurs in coastal regions with an average annual rainfall of 900–2500 mm, usually near the high tidemark but sometimes at higher altitudes. It is recorded to be fairly tolerant to drought. *Hibiscus tiliaceus* is adapted to a wide range of soils, from light to heavy textured ones, acidic to alkaline (pH 5–8.5; optimum: 6–7) and is salt tolerant. It prefers sandy soils rich in organic matter, able to retain moisture.

Hibiscus tiliaceus grows in mangrove vegetation along sandy shores and tidal creeks, in East Africa and tropical Asia often in association with *Barringtonia* spp. It sometimes occurs further inland along rivers and lakes. It is commonly naturalised in disturbed forest areas, fallow or degraded cultivated lands, grazing lands, and around villages.

Propagation and planting Propagation is usually with stem and branch cuttings, but seed may also be used. The germination rate is generally around 50% or higher when seeds are sown directly in the field. The fruits should be harvested from the tree just before turning brown. They are air-dried in paper bags to avoid seeds being lost when the fruits split open. Seeds are removed after a few days by shaking and immediate scarification and sowing is recommended. The seeds germinate 2–4 weeks after sowing in trays. Seedlings are planted out into pots when 5 cm tall, and into the field after 5–6 months when they are about 25 cm tall and 1 cm in diameter. This should be done in the rainy season. For direct planting of cuttings in the field, cuttings 20–45 cm long and 1–3 cm in diameter are recommended. It is important that the lower part of the cuttings is 'wounded' with a sharp knife, to promote side rooting, strengthen the root structure and make the future trees more resistant to winds. If direct plantation is not possible after collection, cuttings can be stored upright in a container with water and kept in the shade. Inoculation of planting material with mycorrhiza helps to improve phosphorus supply. To establish fences, branch cuttings 2–3 m long should be planted as soon as collected, by burying about 1/3 of their length.

Management Cuttings establish in about 4 months, and in dry conditions they should be watered once or twice a week. Regular weeding is necessary. Mulching is useful to control weeds around plants. *Hibiscus tiliaceus*, especially when propagated from branch cuttings, is very competitive and resistant to competition of grasses and other species. Once established, little care is needed. *Hibiscus tiliaceus* coppices readily and, when cut back, produces many long, vigorous shoots with a high fibre production. Where trees regenerate by layering, it can form dense thickets over large areas.

Diseases and pests Few pests and diseases have been reported on natural populations of *Hibiscus tiliaceus*. Like other *Hibiscus* species, it is a host for pests and diseases of closely related crops such as cotton (*Gossypium* spp.).

Handling after harvest Fibre extraction is easy: bark strips are cut and dried in the sun for several days, after which the cork is beaten out and the remaining fibrous material is twisted or plaited into rope.

Genetic resources Some *Hibiscus tiliaceus* accessions are kept in Bangladesh and in the United States. The species itself is not under threat and the propagation ability and the habit of the species make it difficult to eradicate once it has become established.

Breeding Hybridization of *Hibiscus tiliaceus* with other *Hibiscus* species probably occurs in the wild and would be a possible method to generate more productive lines with desired characteristics.

Prospects *Hibiscus tiliaceus* will probably remain a very useful multi-purpose plant in coastal areas, but the use and trade of the fibre are unlikely to increase in the near future. *Hibiscus tiliaceus* has the capacity to improve soil fertility and organic matter content during fallow. The rooting system makes the species a good soil stabilizer.

Major references Burkill, 1997; Chhabra, Mahunnah & Mshiu, 1990; Elevitch & Thomson, 2006; Neuwinger, 2000; Undang A. Dasuki, 2001; Verdcourt & Mwachala, 2009; Wiselius, 1998.

Other references Beentje, 1994b; Boiteau, Boiteau & Allorge-Boiteau, 1999; Chu & Lee, 2004; Coates Palgrave, 1983; Exell & Meeuse, 1961; Gaydou & Ramanoelina, 1984; Keay, 1958d; Kumar, Kumar & Rakash, 2008; Marais & Friedmann, 1987; Nout et al., 1992; Raponda-Walker & Sillans, 1961; SEPASAL, 2011b; van Borssum-Waalkes, 1966; van Wyk & van Wyk, 1997.

Sources of illustration Wiselius, 1998.

Authors E.G. Achigan Dako

Based on PROSEA 5(3): Timber trees: Lesser-known timbers, and PROSEA 12(2): Medicinal and poisonous plants 2.

HIBISCUS VITIFOLIUS L.

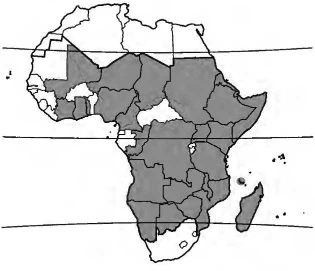
Protologue Sp. pl. 2: 696 (1753).

Family Malvaceae

Chromosome number $2n = 32, 34$

Synonyms *Hibiscus jatrophifolius* A.Rich. (1847).

Origin and geographic distribution *Hibiscus vitifolius* is widespread in mainland tropical Africa from Côte d'Ivoire and Mali eastwards to Eritrea and Somalia and southward to South Africa. It occurs in Madagascar and



Hibiscus vitifolius – wild

the Comoros as well. The species is also recorded for Egypt, Asia and Australia. It has been introduced and has become naturalized in tropical America.

Uses The bark yields a fibre used in West Africa, DR Congo and Kenya for making rope. In Madagascar women use the fibre in handicrafts. The plant is grazed by livestock in Kenya and Tanzania. In Ghana mucilage from the roots is applied to hair and skin to kill parasites. In Kenya the root is used for killing lice. In South Africa Venda people take a root decoction to treat vaginal discharge. In Asia aqueous extracts of the root bark are traditionally used for the treatment of jaundice, inflammation and diabetes. *Hibiscus vitifolius* has ornamental value.

Properties In India fibre from *Hibiscus vitifolius* is considered one of the best-quality fibres in the *Malvaceae* family. It is creamy white, soft and lustrous, with good elasticity and strength, and dyes very well. The ultimate fibres are (0.6–)2.5(–6.7) mm long, with a diameter of (6–)13.5(–21) μm.

The seed contains 13.3% oil on a dry weight basis. Fatty acids present in the seed oil include: palmitic acid 30.1%, stearic acid 4.3%, oleic acid 15.2% and linoleic acid 44.8%. The oil also contains malvalic acid (3.0%) and sterculic acid (0.6%), which are cyclopropenoid fatty acids known to cause physiological disorders in animals.

A flavone, gossypin, and a flavonol bioside have been isolated from the flowers. Further compounds isolated from the flowers are: quercetin, hibiscetin and hibifolin. Gossypin is credited with potent antioxidant and anti-inflammatory activities. It was found to inhibit cell proliferation in tumour cell lines in vitro. It also exhibited anticarcinogenic activities against croton oil induced skin papilloma in mice. The bioside is endowed with significant hypoglycaemic activity. Seeds have shown powerful urease activity. Water and ethanol extracts of the root have shown in-vivo anti-inflammatory and diuretic effects in rats.

Botany Annual or perennial herb or shrub up to 3 m tall, sometimes scrambling, with all parts pubescent to pilose; stem glandular and slightly prickly, sometimes red-tinged. Leaves alternate, simple; stipules linear or filiform, 3–8 mm long; petiole 1–13(–18) cm long; blade broadly ovate to cordiform or suborbicular in outline, 3–15(–19) cm × 2–15.5(–21) cm, unlobed or 3–5(–7)-lobed, base cordate to truncate, lobes triangular, apex acute or acuminate, margin crenate, serrate or undulate, both surfaces glabrous to pubescent, stellate hairs often present. Flowers solitary in leaf-axils or in terminal cymes, regular, bisexual, 5-merous, 5–9 cm in diameter; pedicel 0.5–9 cm long, articulated, pubescent-pilose, rarely tuberculate; epicalyx bracts 8–12, filiform to narrowly triangular, 5–15 mm long, pilose; calyx 10–25 mm long; lobes ovate to triangular, 10–18 mm × 4–10 mm, fused in the lower half, pubescent-hispid, 3–5-veined; petals 2–6 cm long, yellow or lilac with a dark red or maroon blotch at base, glabrous; stamens numerous, united for most of their length into a staminal column up to 16 mm long, free parts of filaments up to 5 mm long; ovary superior, exserted part of style 1.5–5 mm long, glabrous. Fruit a globose to ovoid capsule 7–17 mm × 8–15 mm, on a stalk c. 2.5 cm long, straw-coloured, hispid or pubescent, with 5 wings 2–3 mm wide. Seeds wedge-shaped, c. 3 mm × 2 mm, glabrous, black or dark brown, with evenly-spaced longitudinal rows of tubercles.

In experimental cultivation in India *Hibiscus vitifolius* was classified as a fibre species with a short vegetative phase with only 102 days to reach harvest. Flowering occurred c. 75 days after sowing. At maturity the average plant height was 73 cm with a diameter at the base of 1.25 cm.

Within *Hibiscus vitifolius* three subspecies are sometimes recognized:

- subsp. *vitifolius*: stems and leaves nearly glabrous to sparsely hairy, leaves unlobed to deeply 3–5(–7)-lobed, drying dark green, pedicel articulated at the middle, corolla yellow with a dark blotch at base, capsule 10–17 mm × 9–15 mm; occurring in Cameroon, DR Congo, Ethiopia, Kenya, Uganda, Tanzania, Malawi, Angola, Zimbabwe and Mozambique; also in South Africa and Sri Lanka;
- subsp. *vulgaris* Brenan & Exell: stems and abaxial side of leaves tomentose, tomentellous, densely pilose, densely pubescent or hispid abaxially, leaves not lobed or usually shallowly 3–5(–7)-lobed, drying brownish green; distributed in tropical Africa, South Africa and Asia;
- subsp. *lukei* Mwachala & Cheek: stems and leaves nearly glabrous to sparsely hairy, leaves unlobed to deeply 3–5(–7)-lobed, drying dark green, pedicel articulated above the middle, corolla lilac with a dark maroon blotch at base, capsule c. 8 mm × 8 mm; only known from the type collected in Kenya.

Although many varieties and forms of *Hibiscus*

vitifolius have been published in the past, most authors nowadays are of the opinion that subdivision of the subspecies based on the presence or absence of glandular or hispid hairs, prickles etc. is not meaningful.
Hibiscus comprises c. 200 species, mainly in the tropics and subtropics; many of them grown as ornamentals. Several species yielding fibres are closely related to *Hibiscus vitifolius*. *Hibiscus lunariifolius* Willd. from India has been introduced in Africa and is now found as a ruderal plant in Sierra Leone, Liberia, Ghana, Nigeria, Kenya, Uganda, Tanzania, Angola, Botswana, Zimbabwe and probably elsewhere in tropical Africa as well. It is a shrub or shrubby herb up to 1.5 m tall with densely hairy stems and easily detaching irritating hairs. The fibre is known under the name 'ramma' or 'rama' fibre. Around 1910 the fibre has commercially been produced in Nigeria for a short period, but since then it has been used only locally, for instance for caulking canoes and for making ropes and fishing lines. The leaves are eaten in Ghana and Uganda and the flowers in Ghana and Tanzania. The stems have been used as fire sticks in Ethiopia. The stem bark is used in medicines for the treatment of anaemia, fatigue and listlessness. The powdered leaves are applied to guinea worm sores. *Hibiscus dongolensis* Delile has been confused with *Hibiscus lunariifolius* but it is much less hairy. It is a shrub up to 2 m tall, distributed from Sudan and Eritrea southwards to southern Africa. It has been tested for possible commercial fibre production but fibre quality and yield were disappointing.

Anatomy In a transverse section of *Hibiscus vitifolius* stems harvested at the first pod stage in India the bast fibres occurred in a circle of rectangular wedges. The number of fibre bundles per wedge was c. 21, with c. 4–40 cells per bundle.

Ecology In tropical Africa *Hibiscus vitifolius* occurs from sea-level up to 2400 m altitude in clearings in rainforest, forest edges and paths, secondary forest, woodland, bushland, grassland, roadsides, cultivated land and fallows. In Nigeria it is a weed in rice fields.

Management The 1000-seed weight is c. 6 g. Vegetative propagation is possible as cuttings readily develop roots. Absence of tertiary branching makes the crop easy to handle. In India plants are harvested when they are flowering or bearing small fruits. The leaves are removed and the stems and branches are retted in water for 4–7 days. *Hibiscus vitifolius* is a host plant of the cotton stainer *Dysdercus superstitiosus* and of *Xanthomonas campestris* pv. *malvacearum*, the causal agent of bacterial blight in cotton.

Genetic resources and breeding In view of its widespread distribution in tropical Africa and elsewhere, *Hibiscus vitifolius* is not threatened with genetic erosion.

Prospects *Hibiscus vitifolius* was once featured as promising fibre plant as the quality and physical and chemical properties of its fibre were similar to those of jute (*Corchorus olitorius* L.). However, cultivation of the species has never been seriously promoted. Probably, further agronomic investigations are worthwhile to fully assess the potential of the plant as commercial crop. Cultivation as ornamental plant could also be explored. *Hibiscus vitifolius* exhibits a promising utilization in medicine, particularly with regard to gossypin, a flavone with antioxidant, anti-inflammatory and anti-carcinogenic activities. Further pharmacological research is warranted.

Major references Burkill, 1997; Maiti, 1967; Maiti, 1979; Maiti & Chakravarty, 1977; Verdcourt & Mwachala, 2009.

Other references Arnold & Gulumian, 1984; Babu et al., 2003; Boiteau, Boiteau & Allorge-Boiteau, 1999; Kirby, 1963; Kunnumakkara et al., 2007; Parmar & Ghosh, 1978; Ragunathan & Sulochana, 1994; SEPASAL, 2011c; Singh, Wadhwani, & Johri, 1983; Sundar Rao & Lakshminarayana, 1985; Wilson, 1967.

Authors E.G. Achigan-Dako

HICKELIA MADAGASCARIENSIS A.Camus

Protologue Compt. Rend. Hebd. Séances Acad. Sci. 179: 480 (1924).

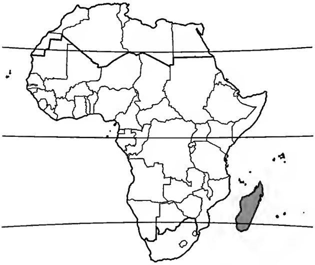
Family Poaceae (Gramineae)

Origin and geographic distribution *Hickelia madagascariensis* is endemic to the central highland of Madagascar, in the provinces Fianarantsoa, Antananarivo and Tamatave.

Uses *Hickelia madagascariensis* is used for wickerwork, such as basket-making.

Production and international trade *Hickelia madagascariensis* is only used and traded locally.

Botany Scrambling bamboo, distance between stems 15–40 cm; lower part of stem erect, upper part and branches pendulous or scrambling over nearby vegetation, about 10–15 m long, with a diameter up to 18 mm with 4 mm thick walls, internodes 25–40 cm long, purplish



Hickelia madagascariensis – wild

green to pale green when young, becoming dull green with age, usually glabrous, pale hairy below nodes, nodes slightly swollen; branches many at each node, leafy branches 20–40 cm long, bearing up to 21 leaves. Leaves on stem alternate; sheath c. 23 cm × 5 cm, narrower towards the tip, only about 7 mm wide at junction with blade, purplish green, with scattered, brown, erect hairs; auricle absent; ligule c. 1 mm long, fringed or deeply toothed; blade erect at first, later spreading, up to 14 cm long, tapering towards the tip, purplish green when young, glabrous; leaves on branches with usually glabrous sheath and blade 8–14 cm × 0.5–1.5 cm, tapering to a fine tip, glabrous or with white scattered hairs below. Inflorescence a panicle 2–5 cm long, terminal on a leafy branch, consisting of few to many spikelets, each branch of the inflorescence subtended by a sheath or bract and with a prophyll at the base; axes hairy; prophylls 2-keeled, symmetrical, or split. Spikelets c. 20 mm long, with 4–5 transitional glumes and 1 fertile floret; lower 2–3 glumes papery, 8–10 mm long, hairy along the margins, with 13–21 veins, upper 2 glumes 10–12 mm long, leathery, shiny; lemma c. 15 mm long, leathery, hairy along the margin, shiny after fertilization; palea c. 15 mm long, leathery, shiny after fertilization; lodicules 3; stamens 6; ovary oblong, usually pubescent in the upper part, with 3 stigmas. Fruit an ovoid caryopsis c. 8 mm long with basal embryo.

Flowering or fruiting plants have seldom been found: flowering plants were collected in 1992, plants bearing fruits but no flowers were collected in 1932.

Hickelia forms part of the *Bambusoideae*. It comprises 4 species, of which 3 occur in Madagascar and 1 (*Hickelia africana* S.Dransf.) is endemic to the southern part of the Iringa Region in Tanzania. *Hickelia africana* is closely related to *Hickelia madagascariensis* and strongly resembles it. It is endemic to an area of only c. 1000 km^2 and seems under threat of genetic erosion, but is not listed in the IUCN Red list. Its slender stems are used as straws to drink bamboo beer made from *Oxytenanthera abyssinica* (A.Rich.) Munro from containers made from another bamboo, *Sinarundinaria alpina* (K.Schum.) C.S.Chao & Renvoize.

Ecology *Hickelia madagascariensis* occurs in humid and subhumid forest in the central highland at 1000–1600 m altitude. It grows in numerous forest pockets and is also found scattered in wasteland or small areas of woodlands in gullies or valleys.

Management *Hickelia madagascariensis* has not been taken into cultivation and there are no reports that it is managed in natural stands.

Genetic resources and breeding *Hickelia madagascariensis* is fairly widespread and seems only occasionally harvested for use. There are no indications that it is in danger of genetic erosion.

Prospects *Hickelia madagascariensis* is likely to remain of limited local use, as well-tested cultivated alternatives are available.

Major references Bystriakova, Kapos & Lysenko, 2004; Camus, 1924; Dransfield, 1994; Ohrnberger, 1999.

Other references Lovett, undated; Quattrocchi, 2006.

Authors L.P.A. Oyen

HIPPOCRATEA MYRIANTHA Oliv.

Protologue Fl. trop. Afr. 1: 369 (1868).

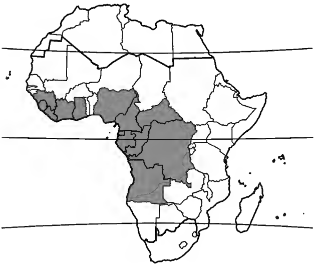
Family Celastraceae (Hippocrateaceae)

Chromosome number $2n = 56$

Origin and geographic distribution *Hippocratea myriantha* is distributed from Guinea to Ghana and from Nigeria to the Central African Republic, DR Congo and Angola.

Uses In DR Congo the stems are used for tying. Because of the considerable strength they are specifically used to lash oil presses.

In traditional medicine in Congo a teaspoon of dried, pulverized leaves is eaten 3 times per week and the abdomen is massaged with the powder to ease childbirth. It helps to induce labour as it stimulates contractions of the mus-



Hippocratea myriantha – wild

cles of the uterus. The dried and pulverized leaves are taken against high blood pressure. The powdered bark is used in mixtures for the treatment of dysentery, and the powdered bark and roots in mixtures against headache and painful ribs.

Properties The wood of *Hippocratea myriantha* is very hard.

Botany A tall liana up to 45 m tall; old main stem with 4 ridges, up to 10 cm in diameter; bark greyish; young branches opposite, glabrous, glaucous whitish blue. Leaves opposite, simple; stipules early caducous, leaving a scar surrounding the stem; petiole 5–13(–20) mm long; blade obovate to ovate, 4–15 cm × 2.5–8 cm, cuneate, obtuse to rounded at base, acuminate to truncate at apex, margin entire or faintly serrate, discolorous, glossy above, with 4–9 pairs of secondary veins. Inflorescence an axillary panicle consisting of paired cymes, dense, soft-hairy, whitish; peduncle of cymes 3–8 cm long, with up to 8 branches. Flowers bisexual, crowded in inflorescence, yellowish or white, 1.5–4 mm in diameter; pedicel 1–2.5 mm long; calyx with 5 equal lobes, soft-hairy; petals 5, free, deltate, 1–1.5 mm long, hairy inside; disk ring-shaped, glabrous, white or green; stamens 3, filaments short, short-hairy; ovary short-hairy, 3-celled, style 3-lobed, very short. Fruit consisting of up to 3 dry, dehiscent, flat mericarps, glaucous when immature, 5–10 cm × 2–3 cm, each 6-seeded. Seeds 4.5–6 cm long, with an oblong, glabrous wing with a marginal and an almost median vein. Seedling with hypogeal germination.

Hippocratea comprises 3 species with 2 of them in tropical Africa. *Hippocratea vignei* Hoyle is very similar to *Hippocratea myriantha* and is distributed from Guinea to Ghana. Many other species have been described in or assigned to the genus but these have ended up in the synonymy of species in related genera. The third species, *Hippocratea volubilis* L., is distributed in Central and South America.

In West Africa *Hippocratea myriantha* flowers in December–June.

Ecology *Hippocratea myriantha* occurs from sea-level up to 1350 m altitude, usually in wet forest, sometimes inundated part of the year, but also in degraded and gallery forest.

Genetic resources and breeding *Hippocratea myriantha* does not seem to be under serious threat by overexploitation or habitat loss.

Prospects *Hippocratea myriantha* will remain useful as a local source of tying material, but no expansion of the use for its fibres or medicinal applications is foreseen.

Major references Burkill, 1985; Hallé, 1962; Hallé, 1986; Wilczek, 1960a.

Other references Adjanohoun et al. (Editors), 1988; Bouquet, 1969; Bouquet & Debray, 1974; Diafouka & Lejoly, 1996; Hawthorne & Jongkind, 2006; Keay & Blakelock, 1958; Lebrun & Stork, 2010; Mangenot & Mangenot, 1957.

Authors C.H. Bosch

HYPARRHENIA FILIPENDULA (Hochst.) Stapf

Protologue Prain, Fl. Trop. Afr. 9(2): 322 (1919).

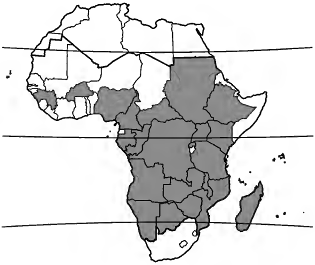
Family Poaceae (Gramineae)

Chromosome number $2n = 40$

Vernacular names Fine thatching grass, fine tambookie grass, fine hood grass (En).

Origin and geographic distribution *Hyparrhenia filipendula* is widely distributed in East and southern Africa, from Sudan, Ethiopia and Kenya south- and westward to Angola and South Africa. Its area of natural distribution extends eastwards through Madagascar, Sri Lanka and Myanmar to Indonesia, the Philippines, Papua New Guinea and Australia. There are also scattered collections from West Africa.

Uses The stems of *Hyparrhenia filipendula* are used for thatching and for making mats and screens for ceilings, outdoor bathrooms and fences for homesteads and homegardens. They are suitable for making paper pulp. When young, the grass provides fair to good grazing and hay; at later stages it becomes too coarse



Hyparrhenia filipendula – wild

to be suitable as forage, although it is still considered palatable during the dry season in Sudan. In Rwanda it is considered to be the most important highland grass species. In traditional medicine in Zimbabwe a decoction of the root is taken against syphilis. *Hyparrhenia filipendula* is occasionally planted as a garden ornamental.

Production and international trade *Hyparrhenia filipendula* is only locally used as thatch or fodder.

Properties According to the South African Standard for fine thatching grass the cut length of *Hyparrhenia filipendula* stems should not be less than 0.8 m, stems should have a minimum and maximum diameter at the butt end of 1.2 mm and 2.5 mm, respectively, be acceptably straight (cut above the first node), be free of loose material, be workable, not be cut in the growing season, be fully grown and matured, and be free of seed when cut.
The forage value of *Hyparrhenia filipendula* at the early bloom stage in Kenya was (on dry matter basis): crude protein 6.6%, crude fibre 36.3%, ash 5.7%, ether extract 1.8%, and nitrogen-free extract 49.5%. Analyses on material from Malawi showed that the nutritional value of the grass decreased with the progress of the growing season: acid detergent fibre increased from 29.6% to 39.0% and finally 46.6%, neutral detergent fibre decreased from 65.6% to 55.6% and finally 47.4%, while ash remained fairly constant at 1.60%, 1.44% and 1.54%.

Adulterations and substitutes Several other *Hyparrhenia* species provide very similar thatching material, while many other grasses and palms leaves are used for the same purpose.

Description Perennial, tufted grass arising from a short scaly rhizome; stems up to 200 cm long, branched from the lower nodes. Leaves alternate; sheath glabrous or rarely with a few stiff white hairs on lower sheaths; ligule up to 1 mm long, membranous; blade linear, up to 65 cm × 8 mm. Inflorescence a false panicle 20–80 cm long, composed of paired racemes, each pair on a peduncle and subtended by a sheathing spatheole; spatheoles linear to almost filiform, 4.5–6.5 cm long; peduncles about as long as the spatheoles, very fine and flexuous, with or without spreading white hairs above; racemes 10–12 mm long, 2–4-awned per pair, delicate, yellowish-green often tinged with violet, terminally exserted, not deflexed; raceme-bases very unequal, the superior raceme (4–)4.5–8(–10) mm long, slender, glabrous, both racemes of a pair bearing basally pairs of homogamous spikelets and towards the apex pairs of heterogamous spikelets. Basal spikelets male or sterile, linear-lanceolate, 5–7 mm long, awnless, glabrous, a single pair at the base of the inferior raceme and 2 pairs at the base of the superior raceme. Upper spikelets in pairs, sessile spikelet fertile, pedicelled spikelet sterile or male; sessile spikelet 4–7 mm long, callus 2–3 mm long, pungent, lower glume linear-oblong, flat on the back or with the inner veins somewhat raised towards the apex, glabrous to villous with white hairs, upper glume awnless, lower floret reduced to hyaline lemma, upper lemma bidentate and with an awn 3–5.5 cm long; pedicelled spikelet linear-lanceolate, 5–6.5 mm long, terminating in an awn 1–5 mm long, callus absent. Fruit an oblong, subterete caryopsis.

Other botanical information *Hyparrhenia* comprises about 55 species classified into 6 sections; it is mainly African but a few species extend into other tropical or warm temperate regions. *Hyparrhenia* specimens are very difficult to identify to species level, As a result of hybridization, apomixis and polyploidy, it consists of a mosaic of intergrading species. *Hyparrhenia filipendula* is classified in section *Polydistachyophorum* series *Filipendula*. It is most easily recognized by its delicate and graceful appearance and the many-branched inflorescence with slender ascending branches, thin and flexuous peduncles, and numerous small racemes with a long upper raceme-base and only 2 awns per pair. Two varieties are recognized in *Hyparrhenia filipendula*: var. *filipendula* and var. *pilosa* (Hochst.) Stapf. The latter is very similar to and easily confused with *Hyparrhenia hirta*, but can be characterized by soft hairy spikelets, combined with the long shaggily hairy awns and longer callus of *Hyparrhenia filipendula*.

Several other species of *Hyparrhenia* are also used for thatching and weaving. *Hyparrhenia barteri* (Hack.) Stapf is an annual grass, with erect stems up to 2(–2.5) m tall, solitary or in tufts. It occurs from Togo and Nigeria eastward to the Central African Republic and southward through Cameroon and the Congo basin to Tanzania, Malawi and Zambia. In Nigeria the stems are used for making rope and mats. *Hyparrhenia cyanescens* (Stapf) Stapf is a robust perennial grass with stems up to 3 m tall, occurring from Senegal eastward to Nigeria and southward to Angola. In northern Nigeria it is used for thatching. It is of little value as fodder as it flowers early. *Hyparrhenia involucrata* Stapf is a robust annual grass up to 2 m tall, occurring from Upper Guinea through Nigeria to Chad and the Central African Republic. The stems are used for thatching and for making mats. *Hyparrhenia subplumosa* Stapf is a robust, perennial grass with stems up to 3 m long. It is widespread in West Africa from Senegal eastward to Cameroon, and is occasionally collected southward to DR Congo and Angola, and eastward to Tanzania and Malawi. The stems are generally considered good thatch. Salka people of Nigeria chop up the stems to serve as reinforcement in mud-blocks for building. The bristly points on the stems make them unsuitable for matting, but they have been recorded to be usable for paper-pulp. Hausa people hold a prejudice against the stems used as brooms lest the user loses his goods and dies. The grass is palatable to cattle when still young.

Growth and development In a pot experiment, weekly or bi-weekly clipping of the leaves at 10 or 15 cm height, combined with irrigation, led to increased leaf growth, while clipping combined with nitrogen fertilizer application led to increased tillering. Only high levels of water and nitrogen combined led to significantly increased yields; the rate of photosynthesis was found to be increased by clipping.

Ecology *Hyparrhenia filipendula* is common in well-drained grassland, open woodland and miombo woodland, from sea-level up to 2250 m altitude. It requires an annual rainfall of at least 625 mm and tolerates a pronounced dry season. In DR Congo it succeeds *Hyparrhenia diplandra* (Hack.) Stapf at elevations below 1700 m when the land is regularly cleared for crop growing.

Propagation and planting *Hyparrhenia filipendula* spreads mainly by seed.

Management At Mt Makulu Research Station (Zambia), cutting *Hyparrhenia filipendula* dominated pastures 2–4 times per year (according to the frequency with which it reached a height of 30 cm) over a period of 9 years changed the botanical species composition of the vegetation. Shorter grasses, such as *Cynodon dactylon* (L.) Pers., *Digitaria milanjiana* (Rendle) Stapf, *Heteropogon contortus* (L.) P.Beauv. ex Roem. & Schult. and *Microchloa kunthii* Desv., became dominant at the expense of *Hyparrhenia filipendula* which resulted in an overall improvement in nutritive value. In Uganda heavy stocking of *Hyparrhenia filipendula* dominated pasture led to its replacement by *Brachiaria decumbens* Stapf, which is a much more nutritious grass. *Hyparrhenia filipendula* grassland generally requires periodic burning late in the dry season. Biennial fires encouraged both *Hyparrhenia filipendula* and *Themeda triandra* in Uganda. Burning late in the dry season in Zambia controls encroachment of *Acacia* spp., but if done too often it leads to decreased plant cover; in a trial, ground cover by *Hyparrhenia filipendula* was halved after repeated burning for 3 years.

Diseases and pests From *Hyparrhenia filipendula* affected by smut, several fungi were isolated. These included *Sporisorium ischaemoides*, *Sporisorium leelingianum*, *Sporisorium transfissum*, and *Sporisorium vanderystii*.

Yield In western Kenya dry matter yields of a *Hyparrhenia* grassland increased from 3670 kg/ha unfertilized to 7595 kg/ha when fertilized with 300 kg N/ha; additional application of 105 kg P_2O_5/ha increased yields to 9885 kg/ha. In the experiment it was concluded, however, that it was uneconomical to fertilize pure natural grassland and that legumes, for instance *Desmodium* species, should be introduced to make better use of fertilizer. In DR Congo *Hyparrhenia* grassland produced 28,800 kg/ha and 25,600 kg/ha of green matter in 2 successive years.

Genetic resources *Hyparrhenia filipendula* is common and often dominant in grasslands in Africa. There are no indications that it is in danger of genetic erosion.

Breeding No selection or breeding work is known.

Prospects *Hyparrhenia filipendula* will remain a valuable source of thatch. It is likely to remain an important component of natural grasslands in tropical Africa and South Africa, although better management will increase the proportion of more nutritious or palatable grasses. It is unlikely that *Hyparrhenia filipendula* will become a component of sown grasslands in Africa or elsewhere, as better forage grasses are available for areas where it can be grown.

Major references Burkill, 1994; Clayton, 1969; Clayton & Renvoize, 1982; Cope, 2002; Keya, 1973; Keya & Kalangi, 1973; Phillips, 1995; Skerman & Riveros, 1990; van der Zon, 1992; van Rensburg, 1968.

Other references Boonman, 1993; Bunda College of Agriculture, 1998; Chippindall, 1955; Chippindall & Crook, 1976; Clayton, 1972; Clayton, 1975; Clayton, Harman & Williamson, 2002–; Coughenour, McNaughton & Wallace, 1985; Dougall & Bogdan, 1958; Gelfand et al., 1985; Harrington & Pratchett, 1974; Myalyosi, 1992; Neuwinger, 2000; South African National Standard, 2004; Williamson, 1955.

Authors S. Kativu

HYPARRHENIA HIRTA (L.) Stapf

Protologue Prain, Fl. trop. Afr. 9: 315 (1919).

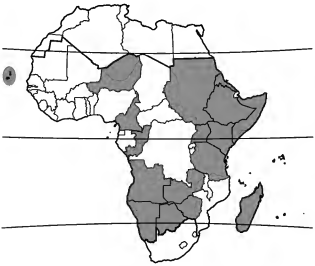
Family Poaceae (Gramineae)

Chromosome number n = 30, $2n$ = 30, 40, 44, 45, 46.

Vernacular names Tambookie grass, common thatch grass, coolatan grass, South African bluestem, hirta grass (En). Barbon, barbon velu, barbon hérissé, herbe barbue (Fr). Palha da Guiné (Po).

Origin and geographic distribution *Hyparrhenia hirta* is mainly distributed in the Mediterranean region and north-eastern tropical Africa, extending eastwards through the Middle East and Arabia to Pakistan. In northern tropical Africa it occurs in Cape Verde, southern Algeria and in isolated locations in Niger. In eastern Africa its distribution range extends from Egypt southwards through Ethiopia to Tanzania, and it occurs again in South Africa, Lesotho and Swaziland. Scattered occurrences are recorded from southern tropical Africa, Madagascar, and Congo. *Hyparrhenia hirta* is naturalized and cultivated in the Americas and Australia.

Uses *Hyparrhenia hirta* is used as a thatching grass and for making mats and baskets. In Lesotho the stems are used for weaving large (up to 2 m tall) baskets for storage of grain. The plant is not suitable for pulping. Young grass is grazed by all stock and can be stored as fair quality hay or silage. Some reports from South Africa state that good hay can be made under proper management. When older, it becomes too coarse and unpalatable to be useful as hay or as a stand-over forage for deferred grazing. In southern Africa and the United States it is recognized as a useful grass for conservation on hard stony soils, and as a pioneer for revegetation of eroded areas.



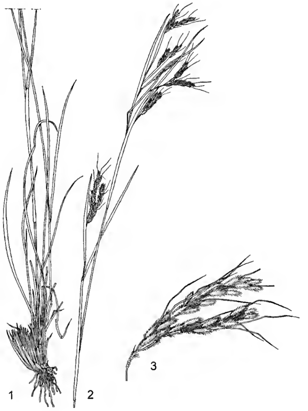
Hyparrhenia hirta – wild

Production and international trade *Hyparrhenia hirta* is only used and traded locally.

Properties According to the South African Standard for fine thatching grass the cut length of *Hyparrhenia hirta* stems should not be less than 0.8 m, stems should have a minimum and maximum diameter at the butt end of 1.2 mm and 2.5 mm, respectively, be acceptably straight (cut above the first node), be free of loose material, be workable, not be cut in the growing season, be fully grown and matured, and be free of seed when cut.

As a forage grass, *Hyparrhenia hirta* is not very palatable, except when very young. Chemical analyses in Kenya indicated the nutritive value of the grass as: crude protein 3.2%, crude fibre 38.1%, N-free extract 45.6%, ether extract 1.8%, total ash 11.3%, digestible crude protein 0.7%, total digestible nutrients 49.6%.

Description Tufted, perennial grass arising from a short rhizome; stems wiry, up to 60(–120) cm tall, above a dense leafy tussock 10–20 cm high. Leaves alternate; sheath compressed and keeled, glabrous or rarely obscurely pu-



Hyparrhenia hirta – 1, base of plant; 2, flowering stem; 3, part of inflorescence.
Redrawn and adapted by Achmad Satiri Nurhaman

berulous at the base; ligule up to 4 mm long, thin-membranous; blade narrowly linear to folded and filiform, 2–20(–30) cm × 1–3(–4) mm, flexuous, glaucous, harshly scaberulous, glabrous or nearly so.
Inflorescence a false panicle up to 30 cm long, scanty with only 2–10 raceme-pairs but sometimes a little fuller, each raceme pair on a peduncle and subtended by a sheathing spatheole; spatheoles linear-lanceolate, 3–8 cm long, reddish; peduncles about as long as the spatheoles, glabrous or with white hairs above; racemes 2–4 cm long, 8–15(–20)-awned per pair, white-villous, exserted, never deflexed, each bearing 4–7(–8) fertile spikelets, the lower raceme of a pair bearing a basal pair of homogamous, sterile or male, pedicelled spikelets, the upper raceme bearing 0–1(–2) pairs of homogamous spikelets. Upper spikelets in pairs, sessile spikelet fertile, pedicelled spikelet sterile or male; sessile spikelet 3.5–6.5 mm long, falling entire and with accessory branch structures, callus 0.5–1.5 mm long, lower glume linear-elliptical, yellowish-green to violet, white-villous but occasionally the hairs rather sparse, upper glume linear and awnless, lower floret reduced to hyaline lemma, fertile floret with linear, membranous lemma with awn 10–35 mm long, palea absent or minute; pedicelled spikelet narrowly lanceolate, 3–8 mm long, white-villous, callus absent. Fruit an oblong, subterete caryopsis.

Other botanical information *Hyparrhenia* is classified into 6 sections and comprises about 55 species, mainly African but with a few species extending into other tropical or warm temperate regions. *Hyparrhenia* specimens are very difficult to identify to species level. As a result of hybridization, apomixis and polyploidy, it consists of a mosaic of intergrading species. *Hyparrhenia hirta* is classified in section *Polydistachyophorum* series *Hirtae*; it is a widespread and variable species which intergrades with several others, including *Hyparrhenia filipendula* (Hochst.) Stapf which has a more graceful, slender habit; with *Hyparrhenia anamesa* Clayton which typically has 2 pairs of homogamous spikelets on the upper raceme, and with *Hyparrhenia rufa* (Nees) Stapf which usually has reddish brown hairs on the spikelets. *Hyparrhenia hirta* is best recognized by its scanty panicle of white-villous racemes which never deflex, by the many-awned racemes with 0–1(–2) homogamous pairs of spikelets at the base of the superior, and by the harsh narrow leaves forming a basal tussock.
Several other *Hyparrhenia* species are used for thatching. Examples in series *Hirtae* of section *Polydistachyophorum* are:

- *Hyparrhenia anamesa* Clayton: a perennial grass forming dense, spreading tufts, with stems 60–120 cm tall, distributed in East and southern Africa from Sudan southward to the Cape area in South Africa, at 100–2500 m altitude. It links the primarily Mediterranean *Hyparrhenia hirta* to the tropical *Hyparrhenia filipendula*. It provides good thatching.
- *Hyparrhenia violascens* (Stapf) Clayton: an annual grass with erect stems up to 1 m tall. It occurs in West Africa, Cameroun and Chad. When mature it is used for thatching and to make coarse matting and door-screens. It furnishes good fodder when young.

Grasses mainly used as thatching material and classified in the related series *Rufae* include:

- *Hyparrhenia finitima* (Hochst.) Andersson ex Stapf: a tufted perennial grass with erect, robust stems 1–2 m long. It occurs widely dispersed in East and southern Africa from

Ethiopia southward to South Africa, and in Sierra Leone, at 900–2000 m altitude. In Zambia it is used for thatching.

- *Hyparrhenia nyassae* (Rendle) Stapf ('bush thatching grass'): a tufted, perennial grass with stems up to 200 cm tall, distributed from Cameroon eastward to Ethiopia and southward to South Africa, at 40–2600 m altitude. In Zambia the stems serve as an inferior thatch. The grain has been eaten in Sudan in times of famine. The grass is browsed by stock while still young and tender.
- *Hyparrhenia smithiana* (Hook.f.) Stapf: a tufted perennial grass with erect, moderately slender stems, occurring in West Africa. Two varieties are recognized: var. *smithiana* with stems 30–90 cm tall, and var. *major* Clayton with stems 1.5–2.5 m tall. Var. *major* yields a good thatch.

Growth and development *Hyparrhenia hirta* follows the C_4-pathway of photosynthesis.

Ecology *Hyparrhenia hirta* occurs in grassland, rocky places and open woodland, in southern Africa mostly in upland dambos. It is found from the shores of the Mediterranean sea up to 2600 m in East Africa. It grows satisfactorily with an annual rainfall of 500 mm or more; in Africa with an average annual rainfall of 750–1000 mm. It is extremely drought tolerant and persistent. It is sensitive to frost and is killed in a hard winter in the United States, but gives some winter growth in South and Western Australia. It occurs on a wide range of soil types, including dry, hard, rocky soils and deep dry sands. It is tolerant of fire. In South Africa *Hyparrhenia hirta*, often together with *Themeda triandra* Forssk., dominates several of the tall-grass- veld vegetation types, particularly in disturbed veld. Long-term overgrazing leads to replacement and dominance of *Eragrostis curvula* (Schrad.) Nees, *Eragrostis plana* Nees and *Sporobolus africanus* (Poir.) Robyns & Tournay. Where selective overgrazing has occurred, particularly by sheep, *Elionurus muticus* (Spreng.) Kunth tends to increase in relative abundance. In a trial with sown *Eragrostis curvula*, *Eragrostis plana*, *Chloris gayana* Kunth and *Digitaria eriantha* Steud. grassland in the Highveld in South Africa, the introduced sown species were replaced by native grasses within a few years; native *Eragrostis* spp. and *Sporobolus pyramidalis* were early invaders, and were later replaced by *Hyparrhenia hirta* which formed nearly pure stands with some broad-leaved species. In Gauteng Province, South Africa *Hyparrhenia hirta* dominated grassland has almost completely replaced the endemic 'Egoli granite grassland', a much more diverse grassland with patchy dominance of many grass species.

Propagation and planting *Hyparrhenia hirta* generally does not spread well by seed. There are about 1.3 million seeds per kg. Below 25°C germination rates are low. In tests in Australia, seed germinated within 24 hours at day and night temperatures of 30°C and 20°C, respectively. Light had a slight positive effect on germination, but not daylength. Germination was good at soil pH 4–10, salinity was disadvantageous.

Management Heavy grazing is tolerated well and is required to prevent plants forming seed and becoming inedible. Top-dressing with 50 kg N/ha in midsummer also extends the period that it can be grazed. *Hyparrhenia hirta* is usually burnt to destroy old growth and it recovers well after fire. It responds well to a spring application of nitrogen. In experiments in south-western Australia, 2 introduced strains showed low nitrogen requirements when heavily defoliated, but responded well to summer and autumn applications.

In Zambia, repeated cutting during 9 years of *Hyparrhenia hirta* dominated grassland led to a marked increase in basal cover of veld grasses. Short grasses, such as *Cynodon dactylon* (L.) Pers. and *Heteropogon contortus* (L.) P.Beauv. ex Roem. & Schult., increased at the expense of tall tussock grasses, but *Hyparrhenia hirta* was little affected and remained dominant.

Diseases and pests From *Hyparrhenia hirta* affected by smut, several fungi of the genus *Sporisorium* have been isolated.

Yield Under irrigation in south-western Australia *Hyparrhenia hirta* produced 24,000–30,000 kg dry matter/ha with six fertilizer dressings totalling 168 kg/ha N, 66 kg/ha P and 180 kg/ha K, plus lime and zinc. In the *Hyparrhenia* veld in South Africa, cattle increase in weight and milk production from late November to March when pasture leaf protein is high (21% in late November, falling to 6% in early April). Thereafter, live weight and milk production decline. In a trial in South Africa *Hyparrhenia hirta* produced about 3 times more above-ground biomass than *Themeda triandra*, *Eragrostis curvula* or *Aristida junciformis* Trin. & Rupr., but after 2 or 4 weeks drought, production of all species dropped to very low levels.

Genetic resources *Hyparrhenia hirta* is widespread and often dominant. As it also responds well to intensive grazing, there are no indications that it is under threat of genetic erosion. Computer models indicate that its range may expand strongly as a result of climate change which may negatively influence the quality of currently productive grasslands.

Breeding No cultivars have yet been established, but 150 distinct forms have been recorded in the introductions into Australia.

Prospects *Hyparrhenia hirta* is likely to remain an important and widely available source of thatch. Its ability to establish on hard stony soils and eroded land and its drought tolerance and persistence make it suitable for revegetation and erosion control. It will remain an important component of natural grazing lands in many parts of tropical Africa, but is likely to remain of little importance in sown grasslands as more palatable and nutritious species are available.

Major references Clayton, 1969; Clayton, 1975; Clayton & Renvoize, 1982; Clayton, Harman & Williamson, 2002–; Cope, 1995; Cope, 2002; Greenwood, 1966; Karue, 1974; Phillips, 1995; Robinson & Potts, 1950.

Other references Bredenkamp, Brown & Pfab, 2006; Chejara et al., 2008; Chejara et al., 2010; CIAT/FAO, undated-b; Davidson, 1962; du Toit, 2010; Evans, 1975; Hardy & Camp, undated; Leigh, 1961; Lodge, McCormick & Harden, 2005; Poilecot, 1999; Risopoulos, 1966; Rogers & Bailey, 1963; South African National Standard, 2004; Vánky, 2003; van Rensburg, 1968; Williamson, 1955.

Sources of illustration Phillips, 1995.

Authors S. Kativu

HYPERTHELIA DISSOLUTA (Nees ex Steud.) Clayton

Protologue Kew Bull. 20: 441 (1966).

Family Poaceae (Gramineae)

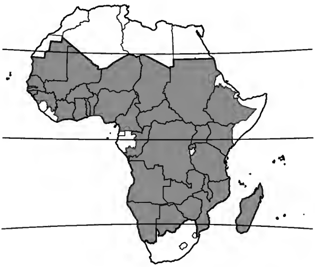
Chromosome number $2n = 40$

Synonyms *Hyparrhenia dissoluta* (Nees ex Steud.) C.E.Hubb. (1936).

Vernacular names Yellow thatching grass, yellow hard grass, coarse thatching grass, yellow tambookie grass (En).

Origin and geographic distribution *Hyperthelia dissoluta* occurs throughout tropical Africa, South Africa and the western Indian Ocean islands, and is introduced and naturalized in tropical America.

Uses Mature stems are widely used for thatching and for making mats after the spikelets have fallen. The mats are used in ceilings, as partition walls and as screens around buildings and compounds. Individual screens are tied serially to make a fence. Dagaari people of Ghana make characteristic square baskets using the younger stems. Cattle eat the grass when it is young. Spikelets are pungently bristled and may injure the muzzle of feeding animals and inhibit browsing, but cattle search for the foliage below the inflorescence. Camels in Niger do not graze it at all.



Hyperthelia dissoluta – wild

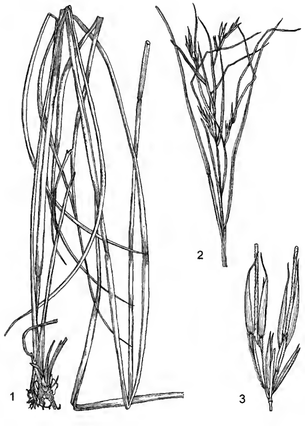
Production and international trade *Hyperthelia dissoluta* is only locally used.

Properties According to the South African Standard for coarse thatching grass the cut length of *Hyperthelia dissoluta* stems should not be less than 1.2 m, stems should have a minimum and maximum diameter at the butt end of 1.2 mm and 2.5 mm, respectively, be acceptably straight (cut above the first node), be free of loose material, be workable, not be cut in the growing season, be fully grown and matured, and be free of seed when cut. The stems have some value for producing paper.

The grass is palatable when young, but too coarse when mature. It is completely grazed in the early stage, but at later stages the stems are usually left ungrazed and only the leaves are eaten. In a survey in South Africa, farmers ranked *Hyperthelia dissoluta* among the less palatable grasses. In Limpopo (South Africa) chemical analysis of the grass indicated per 100 g dry matter (dry matter content 94%): organic matter 90 g, crude protein 2.2 g, neutral detergent fibre 72 g, acid detergent fibre 34 g, in-vitro dry matter digestibility 44% and organic matter digestibility 46%. Analyses of browse species in West Africa indicated for *Hyperthelia dissoluta* (sampled in December) per 100 g dry matter (dry matter content 37%): crude protein 4.3 g, crude fibre 35 g, digestible protein 50%, net energy 3.4 MJ/kg, ash 11.3 g, Ca 0.36 g, P 0.08 g.

Adulterations and substitutes Several *Hyparrhenia* species provide very similar thatching material, while many other grasses and palms leaves are used for the same purpose.

Description Tufted, perennial grass; stems 100–350 cm tall, yellow. Leaves alternate; sheath without auricles; ligule membranous, 2–3(–5) mm long, glabrous; blade linear, up to 30 cm × 6 mm, blue-green. Inflorescence a false panicle, composed of paired racemes subtended by spatheoles, erect, rather stiff, with 4–6 erect, nearly parallel tiers; spatheole narrowly lanceolate, 5–8 cm long, dry membranous, glabrous or sometimes hirsute, yellowish green eventually becoming reddish; peduncle ½–¾ as long as spatheole; racemes paired, erect, 2–3 cm long, 2-awned per pair (occasionally more), the lower raceme of a pair bearing a basal pair of homogamous, sterile or male, pedicelled spikelets 8–15 mm long; rachis filiform, fragile at the nodes, ciliate on margins; raceme-base filiform, unequal, the longer one 2–3 mm long, glabrous, extended into a characteristic, linear to oblong, 4–11 mm long appendage. Spikelets in pairs, sessile spikelet fertile, pedicelled spikelet sterile or male; sessile spikelet linear, 4–14 mm long, falling entire, callus cuneate, 3–6 mm long, white hairy, pungent, glumes dissimilar, exceeding apex of floret, lower glume oblong, coriaceous, deeply grooved, yellow, without keel, apex 2-fid, upper glume oblong, coriaceous, without keel, apex emarginate, unawned, sometimes mucronate, lower floret reduced to hyaline lemma, upper lemma oblong, 5–6 mm long, hyaline, without keel, apex 2-fid, with awn 5–10 cm long, yellowish, stamens 3; pedicelled spikelet lanceolate, 9–14 mm long, pedicel filiform, 4 mm long, setose, tip oblique, callus cuneate, c. 0.5 mm long, acute, glumes coriaceous, one glume with up to 6 mm long awn, lemmas 2, enclosed by glumes. Fruit a narrowly elliptic caryopsis.



Hyperthelia dissoluta – 1, habit; 2, inflorescence; 3, part of inflorescence.
Source: Flore analytique du Bénin

Other botanical information *Hyperthelia* is classified in the *Andropogoneae* and comprises 6 species, all except *Hyperthelia dissoluta* restricted to the area where the Central African Republic, DR Congo and Sudan meet. *Hyperthelia* is closely related to *Hyparrhenia* from which it is distinguished by the deep median groove in its lower glume and by the long appendage from the tip of its raceme-base.

Ecology *Hyperthelia dissoluta* is often a dominant species in tall-grass savanna and is common in deciduous bushland, *Combretum* woodland and wooded grassland, in fixed dunes, along riverbanks and roads and in disturbed places, including mining areas contaminated with nickel and molybdenum. It requires an annual rainfall over 625 mm, and occurs from sea-level up to 1350(–3000) m altitude. *Hyperthelia dissoluta* is commonly found on poor sandy soils. It is tolerant of fire. In East Africa *Hyperthelia dissoluta* dominated grassland is chiefly composed of tall grasses usually associated with *Brachystegia* woodland or a more open *Commiphora* woodland with *Acacia* spp. Soils are generally poor, sandy and derived from granite. These types of grassland occur at 450–1500 m altitude with an annual rainfall of 750–1200 mm falling between November and May. Most grasses are palatable when young but, if not heavily grazed, soon become woody. *Hyperthelia dissoluta* is also common in open, often almost treeless savanna with scattered *Acacia* trees occurring on red and black soils and some flood-plain areas at

450–1200 m altitude with 650–900 mm rainfall.

Propagation and planting *Hyperthelia dissoluta* spreads mainly by seed.

Management In Zambia late dry season burning over a 3 year period of *Hyparrhenia* grassland with *Hyperthelia dissoluta* reduced competition from shrubby vegetation and halved the population of *Hyparrhenia filipendula* (Hochst.) Stapf. However, *Hyperthelia dissoluta* withstood the fires and increased slightly in population.

Diseases and pests From *Hyperthelia dissoluta* affected by smut several fungi have been collected, including: *Sporisorium ischaemoides*, *Sporisorium leelingianum*, *Sporisorium transfissum*, and *Sporisorium vanderystii*.

Harvesting Stems for thatching should be harvested when the plants are fully matured.

Yield In experiments in DR Congo it has produced up to 27 t/ha green matter.

Genetic resources *Hyperthelia dissoluta* is common and has a wide area of distribution. As it is also well adapted to grazing and burning, there are no indications that it is under threat of genetic erosion. On the other hand, it also does not seem to be so dominant under various grazing intensities that it threatens other species or becomes weedy and invasive. No systematic ex-situ collections of germplasm are known to exist.

Prospects *Hyperthelia dissoluta* is likely to remain a valuable and widely available source of natural thatching material. More research is needed to assess its value as a forage in managed grasslands.

Major references Bingham, 1990; Burkill, 1994; Clayton, 1966d; Clayton & Renvoize, 1982; Clayton et al., 2002–; Cope, 2002; Phillips, 1995; Poilecot, 1999; Skerman & Riveros, 1990; Williamson, 1955.

Other references Bogdan, 1977; Brockington, 1961; Cech, Edwards & Olde Venterink, 2010; Chippindall & Crook, 1976; Le Houérou (Editor), 1980; Matlebyane, Ng'ambi & Aregheore, 2009; Matlebyane, Ng'ambi & Aregheore, 2010; Morgenthal, Maboeta & van Rensburg, 2004; Panichev et al., 2008; Sarwatt & Mollel, undated; South African National Standard, 2004; Tobler, Cochard & Edwards, 2003; Vánky, 2003; Williamson, 1955.

Sources of illustration Akoègninou, van der Burg & van der Maesen, 2006.

Authors S. Kativu

HYPHAENE THEBAICA (L.) Mart.

Protologue Hist. Nat. Palm. 3: 226 (1838).

Family Arecaceae (Palmae)

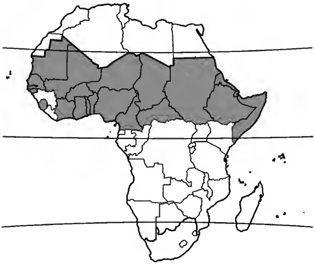
Chromosome number $2n = 36$

Synonyms *Hyphaene dankaliensis* Becc. (1906), *Hyphaene nodularia* Becc. (1908).

Vernacular names Doum palm, Egyptian doum palm, gingerbread palm, gingerbread tree, dum (En). Palmier doum, palmier fourchu, doum, doumier (Fr).

Origin and geographic distribution *Hyphaene thebaica* is distributed from Senegal and Gambia eastwards to Somalia, and is especially common between latitudes 8°N and 12°N. It also occurs in Libya, Egypt, Israel, the Arabian Peninsula and western India. *Hyphaene thebaica* is often planted. It was already cultivated in ancient Egypt, where it was considered sacred.

Uses Strips from the young, unexpanded leaves are widely used for weaving mats, bags, baskets, hats, fans, strainers, bowls, rope, string, nets and coarse textiles. Older leaves are also used for weaving mats, hats, baskets, ropes, containers and other items. In the Sahel ropes for wells are often made from *Hyphaene thebaica*. The midveins of the leaf segments are used as frames for woven objects and tied together they are used as brooms. Whole leaves are used for thatching. In Eritrea the petioles are woven into bed mats and used in the construction of houses, fences and bridges. Fibres from the leaf blade are used for making rough bags, but extraction is laborious and the quality not high. Waste material from fibre extraction is used in Eritrea for stuffing and reinforcing cement. Fibre from the petiole is used for



Hyphaene thebaica – wild and planted

making sponges and brushes. The roots yield a fibre used for making snares and fishing nets and traps.

The trunk is used for house construction, fences, railway sleepers and canoes. Cut into planks it is made into canoes and water wheels. Hollowed trunks are used as water troughs and irrigation pipes. In Mali the wood is used for poles, shafts and harpoons. The wood is also used as fuel and for making charcoal. The leaves, rachis and fruits are used as fuel as well. Ash from the stem is used as a vegetable salt.

The apical bud is eaten as a vegetable ('palm cabbage'). The heart at the base of the trunk is sometimes eaten cooked, and the hypocotyl of seedlings is also cooked and eaten. Sap is extracted from the tree just before flowering for the production of palm wine.

Young leaves and stems are browsed by livestock. In Sudan the young leaves are cut and dried to be used as fodder during the dry season. Older leaves are bitter and unpalatable. The male inflorescence is a fodder in Sudan.

The fruit mesocarp of some trees is inedible, but that of other trees is very palatable, with a sweet, gingerbread-like taste. It is sometimes made into syrup or ground into meal, which is made into cakes and sweetmeat.

The fruits have a hard endocarp, and the 'nuts' are made into balls, toys and weapons. The endocarp is made into small containers. The hard kernel of mature seeds was formerly used as vegetable ivory for the production of buttons, beads and small carvings. The endosperm of unripe seeds is soft and has a cavity holding a liquid which is a much-savoured drink in northern Nigeria. The endosperm of unripe seeds is eaten raw or boiled. Dry fruits yield a black dye, used fur dyeing leather.

In traditional medicine in Mali a paste of the root is massaged on the chest to relieve chest-pain. In Benin a decoction of the leaves of *Hyphaene thebaica* and *Elaeis guineensis* Jacq., the aerial parts of *Indigofera suffruticosa* Mill. and the fruit of *Xylopia aethiopica* (Dunal) A.Rich. is drunk for the treatment of jaundice. A maceration of the root bark is taken for the treatment of intestinal colic and inguinal hernia. In Sudan an infusion of the leaf fibre is used as an eyewash for the treatment of conjunctivitis, and the fruit is eaten against stomach pain and bladder infection. The mesocarp is credited with diuretic properties, and a root extract is drunk in case of blood in the urine.

Production and international trade The 'nuts' were formerly exported, e.g. from Sudan and Eritrea, for the production of buttons and beads from the kernel and small boxes from the endocarp, but nowadays buttons are mainly made from plastic. The fruits are collected to be sold in towns. Bundles of leaf strips to be used for weaving, as well as woven products are traded on local markets.

Properties Fresh leaves contain about 20% fibre, but the yield after decortication is only 12–13%. The fibre is about 40 cm long, and weaker and coarser than jute fibre. The ultimate fibres are (0.5–)1.5–2.1(–3.6) mm long and (10–)13–15(–25) μm wide. Leaf pulp can be made into good-quality paper, but available quantities are too low for commercial production. The ultimate fibres of the rachis are on average 0.8 mm long and 13.7 μm wide, with a cell wall thickness of 3.5 μm and a lumen width of 6.8 μm. Pulps obtained from the rachis by the soda-anthraquinone (soda-AQ), alkaline sulphite-anthraquinone (AS-AQ) and alkaline sulphite-anthraquinone-methanol (ASAM) processes had low strength properties and seemed unsuitable for competitive papermaking. However, blending with kenaf bark pulp gave paper suitable for writing and printing.

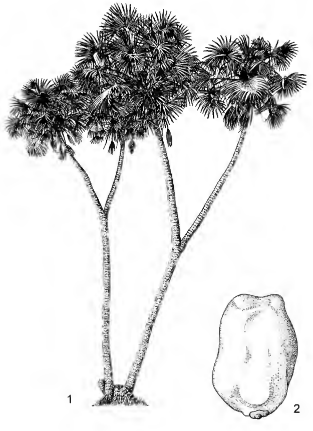
The wood of male trees is said to be hard, tough, durable and resistant to termites, but the wood of female trees is recorded to be more fibrous, less durable and more susceptible to attacks by termites and borers. The wood fibre cells are 0.8–1.5 mm long and 25–45 μm wide. Paper made from pulp obtained from the wood is of inferior quality.

Flour made from the pericarp contains per 100 g edible portion: moisture 10.7 g, energy 1239 kJ (296 kcal), protein 2.6 g, fat 0.4 g, carbohydrates (including fibre) 79.0 g, fibre 14.0 g, ash 7.3 g, Ca 68 mg, thiamine 0.05 mg, riboflavin 0.10 mg and niacin 3.4 mg (Leung, Busson & Jardin, 1968). The kernel contains per 100 g edible portion: moisture 5.7–6.2 g, energy 1654 kJ (395 kcal), protein 2.4–5.0 g, fat 4.9–8.0 g, carbohydrates (including fibre) 80.6 g, fibre 6.5–11.0 g, ash 1.9–5.4 g, Ca 121–168 mg and P 170–281 mg (Leung, Busson & Jardin, 1968). Per 100 g dry matter the seeds contain 1.11 g tannic acid and 330 mg phytic acid.

The dried and ground fruit has shown hypotensive and hypolipidaemic effects. An aqueous extract of the fruit mesocarp stimulated contractions of frog's heart and rat intestine, but inhibited uterine contractions in rats. The extract was capable of lowering the blood pressure in normal and hypertensive dogs, but had no diuretic effects in rabbits, and no oestrogenic and androgenic effects in rats. The aqueous extract contained alkaloids, reducing sugars and glucosides. Ethyl acetate, methanolic and aqueous extracts of the fruit shave shown antibacterial and antifungal activity. Aqueous and methanolic extracts of the fruit have shown antioxidant activity, due to the presence of phenolic constituents. An aqueous extract of the leaf showed strong radical scavenging activity.

Aqueous root suspensions showed hypolipidaemic activity in rats, but were also found to be toxic to both the liver and the kidneys.

Description Dioecious tree up to 20 m tall, with dichotomous branching; trunk solitary, up to 40 cm in diameter, soon dividing into 2 branches, which may divide again to give 8(–16) crowns, most of the trunk covered with leaf bases breaking up into fibres near the base of the trunk. Leaves spirally arranged into dense crowns, with 8–20 leaves per crown, fan-shaped, up to 1.5(–2) m long, sheathing at the base; petiole up to 140 cm long, margins brown or black with spines up to 1 cm long, hastula up to 1.5 cm long; costa up to 3.5(–8) cm long; blade 55–90 cm long, costapalmately divided for up to 75% of its length, with up to 40 segments, with a single fibre between each segment, blue-green; segments single-fold, apex divided, outer half with brown or pale scales. Inflorescence unisexual, axillary, between the leaves; male inflorescence up to 120 cm long, first erect, later pendulous, with a tubular prophyll opening out to a lanceolate blade, partial inflorescences 25–30 cm × 1 cm, rachillae up to 20 cm × c. 1 cm, bracts 7–8 mm × 3 mm and united into a pit with a small opening, flowers 3 per pit, arranged as a cincinnus; female inflorescence similar to male, up to 80 cm long, rachillas usually solitary, rarely 2 together, 12–25 cm × 1–2 cm, flowers 1 in each pit. Flowers unisexual, 3-merous; male flowers with minute green bracts, calyx with tubular base and 3 acute, hooded lobes, corolla with a basal stalk and 3 overlapping, obovate and hooded lobes, stamens 6, on the base of the corolla lobes; female flowers much larger than male ones, pedicel short and wide, sepals 3, free, triangular, acute and leathery, petals 3, rounded, somewhat smaller than sepals, scarious, staminodes 6, ovary globose, 3-locular, but only 1 locule fertile, stigmas 3, sessile. Fruit a drupe, highly variable in shape and size, ovate to globose to obovate, usually with some irregular bumps around the base and/or shoulders towards the apex, 4.5–9 cm × 4.5–7(–8) cm, sessile or with short and wide pedicel, smooth, yellowish brown to orange, red or dark red-brown, dull or shiny, 1-seeded; mesocarp 4–8 mm thick, dry, fibrous; endocarp 3–8 mm thick, bony. Seed shaped like fruit, 3–4 cm × 2.5–4 cm; endosperm white, with hollow centre.



Hyphaene thebaica – 1, tree habit; 2, fruit. Redrawn and adapted by Achmad Satiri Nurhaman

Other botanical information Although more than 40 *Hyphaene* species have been recorded, the genus probably comprises only about 10 species, occurring in the drier parts of tropical and subtropical Africa, with a few species extending into the Middle East and the western coast of India. Its taxonomy is much confused and often misunderstood. It has been revised for East Africa, but a further revision for the other parts of Africa is badly needed. Records of *Hyphaene thebaica* in East Africa usually refer to *Hyphaene compressa* H.Wendl.

Growth and development On germination, the cotyledon stalk buries the radicle and plumule to a depth of 60 cm. The first leaf is strip-shaped; fan-shaped leaves are produced from 2–3 years after germination onwards. The stem forms after 18–20 years. Flowering is usually in the second half of the rainy season. Pollination is by wind. The first fruits are produced after 6–8 years. The fruit ripens in 8–12 months. Elephants and baboons eat the fruits and disperse the seeds. *Hyphaene* spp. are pleonanthic, i.e. the stems do not die after flowering. Stems cut for tapping palm wine die, but the tree coppices from the root. The tree may produce suckers.

Ecology *Hyphaene thebaica* occurs in arid and semi-arid areas with an average annual rainfall of (50–)200–600 mm, from 100 m below sea level up to 1000 m altitude. It is found in river valleys, around oasis, in moist places in grassland and woodland and on floodplains, but also in drier locations. It usually grows on light soils and prefers a pH of 6.5–7.5. *Hyphaene thebaica* withstands fire and tolerates mild frost and moderate salinity, but does not tolerate stagnant water. The presence of the tree is considered an indicator of good soil with a high groundwater table.

Propagation and planting *Hyphaene thebaica* is propagated by seeds and suckers. The 1000-seed weight is 20–50 kg. Direct sowing instead of sowing in nurseries is recommended, as the radicle and plumule are buried deep before germination. Germination may start 1 month after sowing, but can also take up to a year.

After sowing, the soil must be kept moist for 2–3 months, but after that seedlings are able to withstand as much as 10 months drought. In germination trials in Niger freshly collected seeds germinated much better than 13-month-old seeds. Furthermore, untreated seeds had much lower germination than seeds with the pericarp removed and bare nuts (pericarp and endocarp removed). Fresh or 13-months-old seeds that had been soaked in water before sowing had higher germination than unsoaked seeds. The highest germination for freshly-collected seeds was obtained with mechanically-scarified seeds soaked in water for 3 days.

Management The palm can be coppiced and lopped

Harvesting Cutting palm heart or tapping palm wine kills the branch.

Yield An adult tree can produce 50 kg of fruits per year.

Handling after harvest To obtain weaving material, the segments are separated and are made supple by wetting them, the midvein is removed, and the blade is divided into strips, with the width depending on the article to be made. In Eritrea fibre has been extracted from the leaves with machines. Before being decorticated, the leaves were soaked in water for 24 hours. Fibre is obtained from the roots by soaking them for 2–3 days and beating them with pieces of wood.

Genetic resources *Hyphaene thebaica* has a wide distribution area and is often common, but it is locally overexploited and endangered. In Niger, for instance, entire juvenile leaves are cut from young palms too regularly and intensively, resulting in a change of the normal arborescent habit into a subterranean-creeping habit. In Eritrea the felling of living trees is illegal.

Prospects *Hyphaene thebaica* is an extremely useful multipurpose tree for arid and semi-arid regions, yielding fibre, construction material, food, fodder and a range of other products. In Eritrea it plays an important role in food security: it provides food in times of food shortage and the leaves are a source of income. To assure its availability in the future, care should be taken that the species is exploited in a sustainable way. The variability in the fruit quality may offer scope for selection and breeding.

Major references Bein et al., 1996; Bekele-Tesemma, Birnie & Tengnäs, 1993; Burkill, 1997; Edwards & Egziabher, 1997; Jahiel, 1993; Kahn, 2008; Kirby, 1963; Purseglove, 1972; Vanden Berghen, 1988; von Maydell, 1986.

Other references Adjanohoun et al., 1989; Akoègninou, van der Burg & van der Maesen, 2006; Arbonnier, 2004; Balogun & Fetuga, 1988; Dosumu, Nwosu & Nwogu, 2006; Dransfield, 1986; Eldahshan et al., 2008; El-Gendy et al., 2009; Heim de Balsac et al., 1926; Hsu et al., 2006; Irobi & Adedayo, 1999; Janick & Paull (Editors), 2006; Khristova, 2003; Law & Jarman, 1962; Leung, Busson & Jardin, 1968; Mohamed, Khalil & El-Beltagi, 2010; Moussa et al., 1998; Neuwinger, 2000; Sharaf et al., 1972; Zanna et al., 2008.

Sources of illustration Edwards & Egziabher, 1997; Geerling, 1982.

Authors T. Soromessa

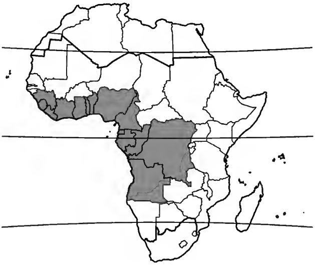
HYPSELODELPHYS POGGEANA (K.Schum.) Milne-Redh.

Protologue Kew Bull. 1950: 160 (1950).

Family Marantaceae

Origin and geographic distribution *Hypselodelphys poggeana* is distributed from Guinea and Sierra Leone to DR Congo and Angola.

Uses The stems are used for tying, in West



Hypselodelphys poggeana – wild

Africa particularly for tying walls and thatch in house construction. In DR Congo the split stems are used for plaiting mats and hats, and entire stems are used for making fish traps. The leaves are used for packing.

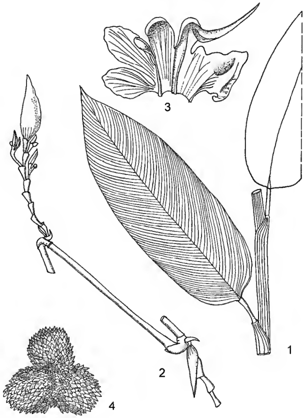
In Liberia the young shoots are chewed with palm kernels, and the juice is credited with aphrodisiac properties.

In Sierra Leone the fruit pulp is eaten, and the seeds are chewed. In Ghana the stems, which are hollow, are used as whistles. In Nigeria the seeds are used for making necklaces. In DR Congo girls sometimes wear a piece of the leafstalk as an ornament in the upper lip.

Botany Perennial, woody, liana-like, branched herb up to c. 6 m tall, with rhizome and bamboo-like shoots. Leaves distichous, antitropic (successively bent to one side and the other); petiole sheathing at the base, jointed shortly above the top of the sheath, above the joint 0.5–1.5 cm long and calloused, calloused part 5–10 mm long, transition of the petiole into the midvein marked by an interruption; blade linear-oblong to ovate-oblong, 7–19 cm × 2.5–9 cm, base truncate, apex acuminate. Inflorescence a simple or slightly branched spike 5–9 cm long from the lowest node; axis articulate and zigzag, with at each node an abaxial, purplish bract 1.5–3.5 cm long enveloping a single cymule; cymule 2-flowered, with an adaxial bract c. 5 mm long, common peduncle short. Flowers bisexual, zygomorphic, purple; bracteole fleshy and hard, sepals 3, free, equal, c. 8 mm long; corolla tubular below, with 3 reflexed lobes, tube c. 15 mm long, lobes c. 5 mm long; staminodes and stamen in 2 cycles, at the base forming a tube fused to the corolla tube, outer cycle consisting of 2 petaloid staminodes, inner cycle consisting of 1 stamen and 2 petaloid staminodes, of which 1 hooded with a sword-like appendage; ovary inferior, 3-locular. Fruit triangular with rounded angles, 4–5 cm in diameter, indehiscent, densely covered with pointed protuberances 1–2 mm long, endocarp pulpy. Seeds without aril.

The flowers are pollinated by bees.

Hypselodelphys comprises 7 species, and is distributed from West Africa eastward to Uganda and southward to Angola. *Hypselodelphys scandens* Louis & Mullend. is a climber up to 10 m long, distributed from Nigeria eastward to Uganda and southward to DR Congo and Angola. Its stems are used for tying and for making fish traps. Its leaves are used for thatching, wrapping and packing. In DR Congo, for instance, they are used for wrapping fish and meat for cooking, and they are said to give a good aroma to the food. In Cameroon they are used as cushion under sleeping mats and made into articles such as cups, funnels, fans and parasols. In traditional medicine in Cameroon root preparations are used for the treatment of sores, headache and heart prob-



Hypselodelphys poggeana – 1, part of leafy stem; 2, part of inflorescence; 3, opened corolla; 4, fruit.
Source: Flore analytique du Bénin

lems. In DR Congo a root decoction is applied as an enema against haemorrhoids. The flexible vines of *Hypselodelphys zenkeriana* (K.Schum.) Milne-Redh., a perennial climbing herb occurring in Cameroon, Equatorial Guinea, Gabon and Congo, are used as poles in hut building in Cameroon. Root preparations are used for the treatment of sores.

Ecology *Hypselodelphys poggeana* occurs in gallery forest, secondary forest and disturbed locations.

Management *Hypselodelphys poggeana* is collected from wild stands.

Genetic resources and breeding In view of its wide distribution and occurrence in secondary forest and disturbed locations, *Hypselodelphys poggeana* is unlikely to be threatened with genetic erosion.

Prospects *Hypselodelphys poggeana* is a useful local source of material for tying, plaiting and packing, but no information is available on its properties and local trade of its products. It is unlikely to become more important, because of the wide availability of other *Marantaceae* and synthetic substitutes.

Major references Burkill, 1997; Hawthorne & Jongkind, 2006; Hepper, 1968c; Koechlin, 1965; Terashima & Ichikawa, 2003.

Other references Abbiw, 1990; Hattori, 2006; Jongkind, 2008; Ku Mbuta et al., 2008; Lubini, 1994; Milne-Redhead, 1950; Missouri Botanical Garden, undated; Pischtschan, Ley & Claβen-Bockhoff, 2010; Terashima, Ichikawa & Sawada, 1988; Terashima, Kalala & Malasi, 1992.

Sources of illustration Akoègninou, van der Burg & van der Maesen, 2006.

Authors M. Brink

HYPSELODELPHYS VIOLACEA (Ridl.) Milne-Redh.

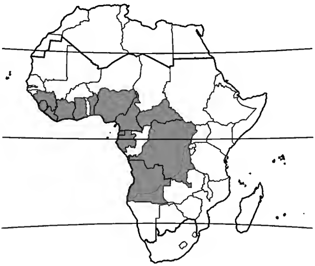
Protologue Kew Bull. 1950: 160 (1950).

Family Marantaceae

Synonyms *Trachyphrynium violaceum* Ridl. (1887).

Origin and geographic distribution *Hypselodelphys violacea* is distributed from Guinea and Sierra Leone eastward to Cameroon, and from there southward to DR Congo and Angola.

Uses The split stems are widely used for tying and making baskets and mats. In Gabon the stems are used for making traps for small animals such as rats and crabs. In Ghana the stems, which are hollow, are used as whistles. The leaves are used for packing.



Hypselodelphys violacea – wild

The fruit is eaten in Sierra Leone, and the seed is chewed in Nigeria. In Benin the leaves form part of preparations drunk for the treatment of hunchback. In the Ubangi river area in Central Africa the dried and powdered fruit is taken as an emetic, and it is eaten in porridge in case of snake-bites.

Properties The fruit is strongly flavoured. The seed is said to have a nutty taste when fresh and almost ripe, but to be tasteless when completely ripe and dry.

Botany Perennial, woody, climbing liana up to c. 3.5(–8) m tall, with rhizome and bamboo-like, branched shoots. Leaves distichous, antitropic (successively bent to one side and the other); petiole generally sheathing up to the joint, above the joint 1–2 cm long and calloused, transition of the petiole into the midvein marked by an interruption; blade linear-ovate to ovate-oblong, 9–22 cm × 2–10 cm, base truncate to rounded, apex acuminate, lower surface with two lines of hairs on both sides of the midvein. Inflorescence a simple or dichotomously branched spike (5–)8–16(–24) cm long from the lowest node; axis articulate and zig-zag, with at each node an abaxial bract 2–3.5 cm long enveloping a single cymule; cymule 2-flowered, with a 2-keeled adaxial bract 10–15 mm long, common peduncle short. Flowers bisexual, zygomorphic, c. 2.5 cm in diameter, purple and white; bracteole fleshy and hard, sepals 3, free, equal; corolla tubular below, with 3 reflexed lobes, c. 2 cm long; staminodes and stamen in 2 cycles, at the base forming a tube fused to the corolla tube, outer cycle consisting of 2 petaloid staminodes, inner cycle consisting of 1 stamen and 2 petaloid staminodes, of which 1 hooded with a sword-like appendage; ovary inferior, 3-locular. Fruit triangular with sharp angles, c. 5 cm in diameter, indehiscent, densely covered with pointed protuberances 1–2 mm long, endocarp pulpy, 3-seeded. Seeds black, without aril.

In Benin flowering and fruiting are probably year-round. The flowers are pollinated by bees.

Hypselodelphys comprises 7 species, distributed from West Africa to Uganda.

Ecology *Hypselodelphys violacea* occurs in secondary forest and forest margins, particularly in humid locations.

Management *Hypselodelphys violacea* is collected from wild stands.

Genetic resources and breeding In view of its wide distribution and occurrence in secondary forest, *Hypselodelphys violacea* is unlikely to be threatened with genetic erosion.

Prospects *Hypselodelphys violacea* is locally used for tying, plaiting and packing, but no information is available on its fibre properties and local trade of its products. It is unlikely to become more important, because of the wide availability of other *Marantaceae* and synthetic substitutes.

Major references Akoègninou, van der Burg & van der Maesen, 2006; Burkill, 1997; Hepper, 1968c; Koechlin, 1965; Vergiat, 1970a.

Other references Abbiw, 1990; Adjanohoun et al. (Editors), 1988; Hawthorne & Jongkind, 2006; Koechlin, 1964; Ley, 2008; Milne-Redhead, 1950; Missouri Botanical Garden, undated; Neuwinger, 2000; Pischtschan, Ley & Claßen-Bockhoff, 2010; Raponda-Walker & Sillans, 1961.

Authors M. Brink

IMPERATA CYLINDRICA (L.) Raeusch.

Protologue Nomencl. bot., ed. 3: 10 (1797).

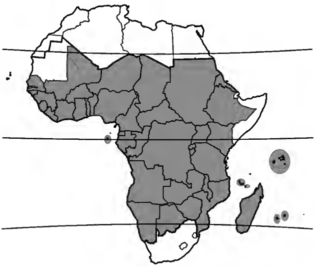
Family Poaceae (Gramineae)

Chromosome number $2n = 20$

Synonyms *Imperata arundinacea* Cirillo (1792).

Vernacular names Speargrass, imperata, cogon grass, alang-alang, lalang, blade grass, blady grass, cottonwool grass, woolly grass, thatch grass, silver spike (En). Herbe à paillotte, paillotte, impérate, chiendent, paille de dys (Fr). Sapé, caminhadora, capin seno, imperata (Po). Unyasi (Sw).

Origin and geographic distribution Speargrass is widely distributed throughout the tropics and subtropics of Africa, the Indian subcontinent, South-East Asia and Australia. It occurs to a lesser extent in North, Central and South America, and is also found in warm temperate areas, being recorded at latitudes of 45° in New Zealand and Japan. In Africa it occurs in almost all countries, including northern Africa and South Africa.



Imperata cylindrica – wild

Uses The leaves and older stems are widely used for thatching. In Nigeria the Igala people bind the grass in rolls and place the rolls on the roof as thatch. The leaves are woven into mats, bags and baskets. In southern Africa the stems and leaves are moistened and twisted into rope, which is considered to be very durable. The seed fluff is used as pillow stuffing and as a substitute for cotton wool in treating sores. *Imperata cylindrica* can be used for making paper, and paper has commercially been produced in Australia.

Young foliage is tender and browsed by cattle and goats, but older leaves become tough and unpalatable and develop razor-sharp edges. Young foliage is also cut as fodder. In Lesotho the rhizomes are eaten raw by herdsmen and in Kenya Kipsigi children chew them for their sweet flavour. Attempts have been made to ferment the rhizomes into a beer and to extract sugar and alcohol from them but without commercial success. Young inflorescences and shoots are cooked and eaten as a vegetable, as the taste is rather sweet. Salt is made from the ash of the aerial parts, and the dried rhizome can be powdered and used as sweetener. Dry plants are burnt as fuel.

Speargrass is used for mulching, for instance in coffee and banana plantations, and the fast-growing rhizomes make it suitable for erosion control and stabilizing slopes. However, it is considered one of the 10 worst weeds in the world.

Speargrass has a range of traditional medicinal uses throughout tropical Africa. A decoction of the rhizome is widely drunk as a diuretic, to purify the blood and to treat dysentery, colic, hypertension and venereal diseases. A rhizome maceration is taken to treat cough, and the pulped-up plant with shea butter (*Vitellaria paradoxa* C.F.Gaertn.) is used as an embrocation for coughs. A decoction of the aerial parts or leaves is drunk to treat fever and malaria and is also used as a wash to treat furuncles and aphthae. In Senegal Fula people drink a rhizome decoction to treat schistosomiasis. In DR Congo ash of burnt roots is rubbed into scarifications to treat chest pain with high fever. Roots are eaten as a galactagogue. Roasted and powdered roots in palm oil are taken as an aphrodisiac. In Uganda the root is chewed to treat snakebites. In Namibia a root decoction is taken to treat jaundice and digestive problems. In southern Africa a crushed root infusion is taken to treat hiccups and indigestion. In Madagascar a decoction of the dried plant is taken as a gargle for sore throat, neuralgia and intestinal worms. In Japan the stems are used in a patented antitumour preparation. Speargrass is also used in various countries in South and South-East Asia for a wide range of medical problems such as fever, nausea, dropsy, jaundice, asthma, haematuria, influenza, emphysema, internal bleeding, nose bleed, cough and kidney diseases. A decoction of the rhizome is commonly applied to purify the blood, as a diuretic and in the treatment of diarrhoea and dysentery.

In Namibia the ground stems are used as a cosmetic. The stems are also cut in short pieces and strung for decorative purposes. A red-leaved ornamental cultivar 'Red Baron' or 'Japanese blood grass' has been developed for garden use in temperate regions.

Production and international trade Speargrass is used only locally and has no importance in international markets.

Properties To give adequate protection from rain, the pitch of roofs to be thatched with speargrass has to be steep and the thatch about 20 cm thick, requiring a strong support. This type of thatch may last 2–3 years. Plant material from Nigeria (mainly leaves, with thin stems and some rhizome parts) investigated in the 1910s contained 46% cellulose on a dry matter basis. The fibre cells were (0.6–)0.8–1.1(–1.3) mm long. Leaf material from Sri Lanka (mainly leaf blades, with a small proportion leaf sheaths) investigated in the 1930s contained 46% cellulose on a dry matter basis. The fibre cells were (0.2–)0.5–1.5(–3.0) mm long and (4.7–)6–9(–15.5) μm wide.

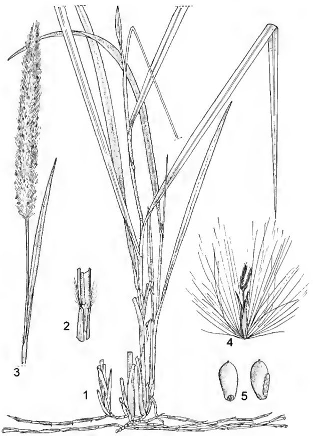
Speargrass is considered a low quality forage. Nitrogen concentrations may only remain above 1% for some 6 weeks when it grows rapidly, but can remain above this level for up to 20 weeks with slower growth rates at higher latitudes and altitudes. Very young growth may have a digestibility of 70%, falling to below 40% after 150 days. Where there is opportunity for selective grazing, other species are usually preferred.

The rhizome contains the biphenyl ethers cylindol A and B, the phenolic compound imperanene, the sesquiterpenoid cylindrene, the lignans graminone A and B and several chromone derivatives. It also contains about 19% sugars (saccharose, dextrose, fructose, xylose) and various acids (including malic, citric, tartaric, chlorogenic, coumaric and oxalic acid). From the aerial parts serotonin and the triterpenoids arundoin, cylindrin, fernenol, isoarborinol and aimiarenol were isolated. Cylindol A has shown 5-lipooxygenase activity, which may be partly involved in the reputed anti-inflammatory activity of speargrass. Imperanene has shown inhibitory activity against rabbit platelet aggregation. Cylindrene and graminone B have shown inhibitory effects on rabbit aorta contraction. Several chromone derivatives showed significant neuroprotective activity against glutamate-induced neurotoxicity in rat cortical cell cultures.

An aqueous extract of stem and leaves has shown some antitumour activity against sarcoma 180 and adenocarcinoma 75 in mice. Rhizome extracts significantly inhibited urination in rats.

Besides the above pharmacological activities, antiviral, antihepatotoxic, antihypertensive, antihistamine and larvicidal activities are also reported, as well as an allelopathic effect on the germination and growth of other plant species.

Description Perennial herb up to 120(–300) cm tall; rhizome deeply buried, white, branched, fleshy and scaly; stems solitary or tufted, erect, unbranched, solid, with 1–4(–8) nodes, nodes glabrous to hairy. Leaves mostly basal; sheath with ciliate margin, lower sheaths broad and leathery, overlapping; ligule membraneous, up to c. 1 mm long; blade linear-lanceolate, 10–80(–180) cm × 0.5–2.5 cm, flat or rolled, erect, spread-



Imperata cylindrica – 1, habit; 2, ligule; 3, inflorescence; 4, spikelet; 5, two views of the caryopsis.
Source: PROSEA

ing or drooping, long-acuminate at the apex, long-hairy at the base, older leaves with hard, serrate, cutting margins and a stout whitish midvein. Inflorescence a terminal, spike-like panicle, cylindrical, 6–30 cm × c. 2 cm, branches ascending close to the main axis. Spikelets in pairs, 3–6 mm long, 2-flowered, at the base with a dense whorl of silky white hairs up to 2.5 cm long; pedicels unequal, up to 1 mm long; glumes equal, 3–9-veined; lower floret reduced to a hyaline lemma; upper floret bisexual, lemma ovate, c. 1 mm long, palea hyaline, lodicules absent, stamens 2, anthers orange to purple, stigmas 2, purple. Fruit an ellipsoid caryopsis (grain) c. 1 mm long, brown.

Other botanical information *Imperata* comprises about 10 species and originates in the New World. It is divided into two sections, based on the number of stamens: section *Imperata* (2 stamens) with only 1 species (*Imperata cylindrica*), and section *Eriopogon* (1 stamen). A number of varieties have been described for *Imperata cylindrica*, often related to geographical regions. However, as these varieties more or less intergrade, the distinction is usually ignored.

Growth and development The optimum temperature for growth of speargrass is about 30°C with negligible growth at 20°C and 40°C. The rhizomes are highly competitive and penetrate the roots of other plants, causing rot or death. In a controlled greenhouse experiment young plants initiated new rhizomes between the third and fourth leaf-stages. Rhizome growth is determinate, with the apical bud forming a shoot and sub-apical buds forming rhizome branches. Under favourable conditions, apical and sub-apical buds develop simultaneously, but under stress the growth of the apical bud is favoured. Roots and buds develop at the distal nodes of the young rhizome long after the rhizome has been formed. Flowering is variable between individual plants and stands, but generally occurs in spring or fall, and often in response to a range of disturbances (e.g. burning, mowing, soil disturbance) throughout the year. Frequent fires encourage the growth and uniformity of the population. Seedlings establish well after burning. Incapable of self-pollination, speargrass produces viable seed only when cross-pollinated and the success rate of outcrossing is low, less than 40% in natural populations. Still, speargrass may produce as many as 3000 seeds per plant. Seeds are dispersed by wind, up to 100 m away. Speargrass is a C_4 plant.

Ecology Speargrass occurs from sea-level up to 2000(–2700) m altitude in a wide range of open, anthropogenic habitats, preferring well-aerated soils. It is often found in areas with an average annual rainfall over 1000 mm, but has been recorded in sites receiving from 500 to 5000 mm per year. It will grow in full sun as well as in light shade. Speargrass tolerates temperatures down to about −15°C when dormant, but young growth in spring in temperate climates can be damaged by late frosts. Speargrass generally occurs on light-textured acid soils with a clay subsoil, but can tolerate a wide range of soils from strongly acidic to slightly alkaline, with a pH of 4.0–7.5, although germination is promoted by a pH lower than 5. It grows most vigorously in wet soil of reasonable fertility, and can even tolerate very hot, sulphurous conditions in active volcanic areas. Speargrass can withstand waterlogging but not continuous flooding; it is salt-tolerant.

Speargrass is one of the most noxious colonizers of degraded humid tropical forest soils and often invades abandoned shifting cultivation fields. The tendency to form dense, persistent and expanding stands allows it to displace other vegetation. Its abundant biomass prevents establishment of other plants and changes the properties of the litter and upper soil layer.

Propagation and planting Speargrass is propagated by seed or rhizomes. The seed has no dormancy and seeds may show 95% germination within one week after maturation. Seed germination in the dark increased from 9% at 20°C to 55% at 30°C and declined somewhat at 35°C. Germination was about 70% in the light with alternate 12-hour periods at 20°C and 30°C. Addition of 0.2% KNO_3 solution increased germination in the dark, but not in the light. Germination declined gradually after 13 months of storage. Rhizomes are very resistant to heat and breakage, and may penetrate soil up to 1.2 m deep, but generally occur in the top 15 cm in heavy clay soils, and 40 cm of sandy soils. Rhizome biomass can reach 40 t/ha fresh weight and regrowth potential of roots is a critical issue in development of control methodologies, including biological control. Rhizomes accidentally cut by cultivation can re-establish from pieces as small as 5 mm. Success of segment regeneration is determined by the original location of the segment on the rhizome, including proximity to, or inclusion of, axillary and apical buds, as well as by environmental conditions. Vegetative reproduction from rhizomes is a significant factor in human spread of the species because these are often found in dirt moved as fill.

Management Speargrass is favoured by burning, which can lead to virtually monospecific populations, also called 'swards'. If speargrass is to be used for thatching, populations are left ungrazed until after the mature growth has been cut. It has been suggested that speargrass that is used regularly for grazing should be grazed rotationally when 15–25 cm high. Because of its aggressiveness and low quality, it is widely regarded as a weed and research has been carried out on improving its quality through introducing legumes or even replacing it with other grasses. However, it is not easy to maintain herbaceous legumes with speargrass, though some promising results have been achieved with stylo (*Stylosanthes guianensis* (Aubl.) Sw.) and leucaena (*Leucaena leucocephala* (Lam.) de Wit).

Throughout the tropics, including natural grasslands, speargrass covers an area estimated at 5,000,000 km², of which 2,000,000 km² in South-East Asia. Speargrass can best be suppressed by an integrated management strategy, including different cover crops, heavy continuous grazing, frequent cutting, frequent cultivation and chemical and/or biological control, although these last 2 methods are generally considered to be too expensive.

Frequent cutting and frequent mechanical cultivation, however, may result in loss of fertility. Forking and removal of the rhizomes by hand is completely effective but this is only practical if infestation is light and sporadic and the area small.

Diseases and pests There are no records of major diseases or pests for speargrass.

Harvesting For thatching, the longer the grass the better, and the leafy stems should be cut after the seed has ripened but before the plant has dried out and become brittle. The cut plants must be combed to remove the soft leaves and short pieces and should then be dried, after which they are tied in bundles about 20 cm in diameter. For medicinal purposes, plants are simply uprooted to collect the rhizomes, or aerial parts are harvested whenever the need arises.

Yield Reported above-ground dry matter yields of speargrass are 2–12 t/ha per year. In Indonesia a production has been recorded of 11 t/ha of leaves and 7 t/ha of rhizomes, with on average 4.5 million shoots.

Handling after harvest Harvested plant parts are usually dried before being used as thatch, or used fresh as fodder or for medicinal purposes.

Genetic resources Speargrass is widespread and common, usually even considered a noxious weed. Its spread is favoured by human activities, and it is therefore certainly not threatened by genetic erosion.

Breeding The red-leaved ornamental cultivar 'Red Baron' or 'Japanese blood grass' has been reported to be able to revert to the green, invasive form, especially when the plant has been propagated by tissue culture.

Prospects Although speargrass is widely considered a serious weed, it can be useful for various purposes, especially to provide thatching material when mature and fodder when young. Its use to control erosion is valuable as well, but alternatives should be tested before using it. A broad range of medicinal uses has been reported, but most claims still need to be validated. Most research on speargrass is focused on finding the most efficient and cheap ways of eradicating it from farm land. As with most highly invasive weeds, an integrated management strategy seems the only viable way.

Major references Aguilar, 1992; Bolfrey-Arku, 2004; Burkill, 1994; Chikoye, Ekeleme & Gbehounou, 2004; Juliana Jonathan & Bambang P.J. Hariadi, 1999; Loewenstein & Miller (Editors), 2007; Van Loan, Meeker & Minno, 2002; Wright et al., 2007; Yandoc, Charudattan & Shilling, 2005; Yoon et al., 2006.

Other references Achinah, N.K.A., 2009; Adjanohoun & Aké Assi, 1979; Anonymous, 1921; Anonymous, 1937; Ayeni & Duke, 1985; Bazira, Bekunda & Tenywa, 1997; Coile & Shilling, 1993; Darko, 2009; English, 1998; Eniola-Tijani & Fawusi, 1991; Faihun, 2001; Gaffney & Shilling, 1996; Holm et al., 1977; Matsunaga et al., 1994; Matsunaga, Shibuya & Ohizumi, 1994a; Matsunaga, Shibuya & Ohizumi, 1994b; Matsunaga, Shibuya & Ohizumi, 1995; Neuwinger, 2000; Shilling et al., 1997; Terry et al., 1997.

Sources of illustration Aguilar, 1992.

Authors J.P. Lepetu

JULBERNARDIA GLOBIFLORA (Benth.) Troupin

Protologue Bull. Jard. Bot. Etat 20: 314 (1950).

Family Caesalpiniaceae (Leguminosae - Caesalpinioideae)

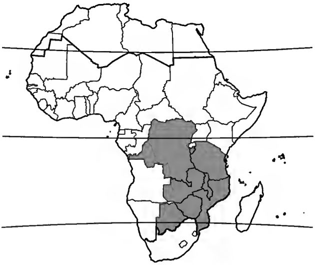
Chromosome number $2n = 24$.

Synonyms *Brachystegia globiflora* Benth. (1881), *Isoberlinia globiflora* (Benth.) Hutch. ex Greenway (1928), *Pseudoberlinia globiflora* (Benth.) P.A.Duvign. (1950).

Vernacular names Mwongo, myombo (Sw).

Origin and geographic distribution *Julbernardia globiflora* is distributed from DR Congo, Burundi and Tanzania southward to Botswana, Zimbabwe and Mozambique.

Uses The inner bark is an important local source of string and rope used for tying, e.g. in construction. The bark is also used for making beehives, stitched canoes, bins and sacks. In Tanzania the bark is used to roll rings to carry baskets on the head. Larger pieces of bark are used in Tanzania for making containers, seats and doors. In Zimbabwe the bark fibre is used for making the warm and pliable 'gudza' cloth, which is made into garments and household items, such as storage bags and beer strainers. The bark was formerly made into bark cloth. In Burundi fibre from the root is made into fishing lines.



Julbernardia globiflora – wild

The wood is used for poles, tool handles, mortars, yokes, harnesses and canoes. It is also suitable for railway sleepers, mine props, construction, flooring, shipbuilding, vehicle bodies, furniture, sporting goods, interior trim and joinery. The wood is widely used as fuelwood and for making charcoal.

The bark yields a tannin used for dyeing. The tree provides fodder, and it is an important early-season browse plant in southern Zimbabwe. It is a bee forage, yielding honey of very high-quality, and an important food plant for edible caterpillars. The tree has ornamental value for its fragrant flowers and beautiful shape, and it provides shade. In Zimbabwe farmers gather *Julbernardia globiflora* leaf litter from adjacent woodlands to improve the soil fertility of their fields; it is sometimes moved to kraals and composted with manure before being applied to fields.

In African traditional medicine root decoctions are drunk for the treatment of depression and stomach problems. In Zimbabwe and Tanzania decoctions of the bark are dropped into the eye against conjunctivitis, and in Zimbabwe a bark infusion is used as a wash to contract the vaginal canal. Bark fibres are chewed in case of constipation, and tannin from the bark has been used as a laxative. Stem pieces are ground and smoked for the treatment of leprosy. In case of snakebite, the leaves of *Julbernardia globiflora* are rubbed into scarifications around the wound after the poison has been sucked out. Infusions of the bark or root have been drunk as ordeal poisons in Zambia, and also in Zimbabwe the tree is used for trial by ordeal. In veterinary medicine in Zimbabwe an infusion of the bark is instilled against diarrhoea in cattle.

Production and international trade The fibre of *Julbernardia globiflora* is not traded internationally. In rural areas in tropical Africa small quantities are locally traded. Charcoal and wood from rural areas are traded to supply towns.

Properties Quantitative information on the fibre properties is not available, but string or rope made from the bark fibre is recorded to be inferior to that from *Brachystegia* species.

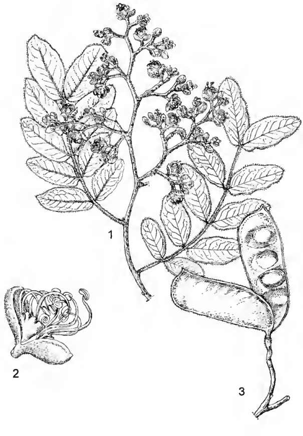
The heartwood is brown and distinctly demarcated from the up to 15 cm wide, pink or pale yellowish brown sapwood. The grain is interlocked, texture moderately coarse to coarse and uneven. The wood is lustrous. The density of the wood is 820–960 kg/m³ at 12% moisture content. The wood seasons slowly, with a strong tendency to distortion and moderate surface checking and end splitting. The rates of shrinkage from green to 12% moisture content are 2.9% radial and 3.6% tangential, from green to oven dry 4.8% radial and 6.0% tangential. Movement in service is medium. The wood is strong and hard. At 12% moisture content, the modulus of rupture is 97–147 N/mm², modulus of elasticity 12,400–15,600 N/mm², compression parallel to grain 57–81 N/mm², shear 14–20 N/mm², cleavage 16–72 N/mm radial and 17–74 N/mm tangential, Janka side hardness 1100–7700 N, and Janka end hardness 9600 N. The wood is difficult to work with hand and machine tools, blunting these tools rapidly. Surfaces may tear during planing and moulding, and low speeds are recommended to improve results. The wood tends to split upon nailing, making pre-boring necessary, but it holds nails well. It is not well-suited for turning. The steam-bending properties are moderate. The heartwood is durable, but liable to attacks by pinhole borers, marine borers and termites. The sapwood is liable to powder-post beetle attack. The heartwood is impermeable to preservatives; the sapwood is variably resistant to impregnation, with the outer zone being most permeable. The wood yields paper pulp of poor quality.

Per 100 g dry weight the bark contains 24.8 g tannin, the sapwood 3.2 g and the heartwood 6.1 g. In Zimbabwe *Julbernardia globiflora* browse (leaves and thin twigs) contains per 100 g dry matter: crude protein 15.5 g, neutral detergent fibre 55.6 g, acid detergent fibre 53.8 g, acid detergent lignin 11.1 g. The fatty acid composition of the seed oil is approximately: palmitic acid 35.4%, linoleic acid 33.5%, oleic acid 19.8%, stearic acid 7.6%, arachidic acid 1.5%, behenic acid 1.0%, lignoceric acid 0.7%, linolenic acid 0.5% and myristic acid 0.1%.

The root, bark and leaf have been recorded to be toxic: drinking an infusion of the leaf causes vomiting and drinking an infusion of the root or bark may cause a person to lose speech, to foam at the mouth and to roll about as if in pain.

Adulterations and substitutes Fibre and wood is also obtained from *Brachystegia spiciformis* Benth., which often grows together with *Julbernardia globiflora*. The bark of *Brachystegia boehmii* Taub. is also used for making 'gudza' cloth.

Description Deciduous, small to medium-sized tree up to 15(–20) m tall, sometimes shrubby; bole branchless for up to 6 m, up to 90 cm in diameter, often crooked; outer bark rough, grey; crown flattened or rounded, spreading; young branches pubescent, soon glabrescent. Leaves alternate, paripinnately compound with (2–)4–6(–8) pairs of opposite leaflets; stipules intrapetiolar, 3–5 mm long, connate at base, bicuspidate, caducous; petiole (1–)1.5–3(–4) cm long, hairy; rachis 4–17 cm



Julbernardia globiflora – 1, flowering twig; 2, flower; 3, dehisced fruit.
Redrawn and adapted by Iskak Syamsudin

long, hairy; petiolules twisted, 2–3 mm long; leaflets oblong-elliptical, oblong-lanceolate, ovate-oblong or obovate-oblong, (1–)2–8.5(–11.5) cm × (0.5–)1–3.5(–5.5) cm, base asymmetrically cuneate, apex obtuse to emarginate, margin entire, fringed with white hairs, venation prominent on both surfaces. Inflorescence a terminal panicle up to 30 cm × 30 cm, brown-hairy; bracts 2–10 mm long. Flowers bisexual, fragrant, 5-merous; pedicel 2–6 mm long; bracteoles 2, valvate, 7–10 mm × 6–9 mm, keeled on the back, persistent; sepals 5, oblong, 2.5–4.5 mm × c. 1.5 mm, non-contiguous; petals 5, pale yellow to white, 1 large and 4 small, the larger one ovate, 6.5–9 mm × 4–5 mm, shortly clawed, the others oblanceolate, narrowly obovate or linear, 3–8 mm × 0.5–3 mm; stamens 10, up to 13 mm long, 9 filaments shortly connate, 1 free; ovary superior, very shortly stipitate, style elongate, stigma capitate. Fruit an obovate-oblong or oblong pod 4–9 cm × 2–3.5 cm, flattened, brown-tomentose, 3–4-seeded, explosively dehiscent into 2 woody valves becoming spirally twisted. Seeds c. 1.5 cm × 1–1.5 cm, flattened, dark brown.

Other botanical information *Julbernardia* comprises about 10 species, all in tropical Africa.

Anatomy Wood-anatomical description (IAWA hardwood codes):

Growth rings: (1: growth ring boundaries distinct); (2: growth ring boundaries indistinct or absent). Vessels: 5: wood diffuse-porous; 13: simple perforation plates; 22: intervessel pits alternate; 23: shape of alternate pits polygonal; 25: intervessel pits small (4–7 μm); 26: intervessel pits medium (7–10 μm); 29: vestured pits; 30: vessel-ray pits with distinct borders; similar to intervessel pits in size and shape throughout the ray cell; 42: mean tangential diameter of vessel lumina 100–200 μm; 46: ≤ 5 vessels per square millimetre; 47: 5–20 vessels per square millimetre. Tracheids and fibres: 61: fibres with simple to minutely bordered pits; 66: non-septate fibres present; 69: fibres thin- to thick-walled; (70: fibres very thick-walled). Axial parenchyma: 79: axial parenchyma vasicentric; 80: axial parenchyma aliform; 81: axial parenchyma lozenge-aliform; 83: axial parenchyma confluent; (85: axial parenchyma bands more than three cells wide); 89: axial parenchyma in marginal or in seemingly marginal bands; 92: four (3–4) cells per parenchyma strand. Rays: 97: ray width 1–3 cells; 104: all ray cells procumbent; (106: body ray cells procumbent with one row of upright and/or square marginal cells); 115: 4–12 rays per mm. Mineral inclusions: 136: prismatic crystals present; 142: prismatic crystals in chambered axial parenchyma cells.

(D. Louppe, P. Détienne & E.A. Wheeler)

Growth and development Natural regeneration from seed is rare, but trees resprout vigorously after cutting. In dry miombo woodland in Zimbabwe the mean stem height of regrowth at 1, 2, 3, 9 and 18 years after cutting was 67, 110, 141, 247 and 517 cm, respectively. Plants only 1.5 m tall can already produce seed, especially when of coppice origin. In southern Africa flowering is in (November–) February–May and fruiting in May–November, but trees often do not fruit yearly. The tree has an extensive root system, with a maximum recorded lateral distance of 27 m. *Julbernardia globiflora* does not form root nodules.

Ecology *Julbernardia globiflora* occurs at 250–2000 m altitude in deciduous woodland, usually with an average annual rainfall below 1000 mm, a dry season of 7–8 months, and subject to regular fires. It is widespread and abundant, and often dominant or co-dominant in dry miombo woodland, usually occurring with *Brachystegia spiciformis* and forming tsetse-fly habitats. In southern Africa it occurs especially in drier areas and on poor soils of plateaus and slopes.

Propagation and planting *Julbernardia globiflora* can be propagated by seed or suckers. The 1000-seed weight is 260–670 g. Germination takes 5–25 days, and germination rates of 73% have been recorded under field and laboratory conditions. The germination of seeds stored for a year was only 35%. Under experimental field conditions in Zambia, the seedling mortality rate was about 60% during the first year.

Management *Julbernardia globiflora* is not planted, but wild trees are sometimes protected. It coppices well, but trees cut close to the ground (<5 cm) produce less coppice growth than plants cut at 1.3 m height. In Zimbabwe lopping of branches is carried out in the late dry season to make browse accessible to livestock.

Diseases and pests The scale insect *Aspidoproctus glaber* has caused extensive die back and even tree death of *Julbernardia globiflora* and *Brachystegia* spp. in Zimbabwe.

Harvesting In Tanzania the large pieces of bark used for containers or used as doors are traditionally harvested by men. They select old trees with straight boles and few branches and use long knives to cut the shape of the demanded piece and tear it off slowly from the stem. Smaller pieces of bark and strings are harvested traditionally by women and children. They often do not use tools or use small knives to tear off long bark strips. Sometimes they use long knives to cut off larger pieces of bark to be used as seats, lids for pots and other household items. Poles are obtained by pruning the tree.

Handling after harvest In southern Africa large sections of bark cut from mature trees were normally buried in the ground to loosen the corky outer layer, which was subsequently gradually loosened with special tools, so that only a sheet of fibres remained. This sheet could be stretched and softened to be used as a blanket. More commonly, the inner bark was woven or knotted to make 'gudza' cloth and 'nhova' bags.

Genetic resources *Julbernardia globiflora* is widespread and abundant, but harvesting for timber and fuelwood is often done in an unsustainable way. Harvesting of thin strips and small pieces of bark can be done without severe damage to the tree.

Prospects *Julbernardia globiflora* is a useful local source of fibre, fuel, timber and other products. Small quantities of the fibre are locally traded, but the potential in larger markets is limited because of the availability of cheaper, synthetic substitutes in towns. Natural stands are often exploited unsustainably, but *Julbernardia globiflora* resprouts vigorously after cutting, and natural stands could be exploited using coppice rotations as a silvicultural system. Various plant parts are used in traditional African medicine, mainly externally. As the root, bark and leaf are sometimes said to be toxic, internal use seems not advisable.

Major references Brummitt et al., 2007; Campbell, 1996; Chileshe & Kitalyi, 2002; Chilufya & Tengnäs, 1996; Gelfand et al., 1985; Luoga, Witkowski & Balkwill, 2004; Neuwinger, 2000; USDA Forest Service, undated; van Wyk & Gericke, 2000; Watt & Breyer-Brandwijk, 1962.

Other references Allen & Allen, 1981; Bolza & Keating, 1972; Bryce, 1967; Chidumayo, 1991; Chidumayo, 1997; Drummond, 1981; Greenway, 1950; Heine & Legère, 1995; Karmann, 2003; Luoga, Witkowski & Balkwill, 2000; Mndolwa, Lulandala & Elifuraha, 2008; Ndlovu & Nherera, 1997; Nyoka, 2003; Pelter et al., 1969; Reekmans, 1981; Stamp, 1998; Stefanesco & Bintoni-Juliassi, 1982; Storrs, 1995; Takahashi, 1978; Wehmeyer, 1986.

Sources of illustration Brenan, 1967a.

Authors L. Jimu

JULBERNARDIA MAGNISTIPULATA (Harms) Troupin

Protologue Bull. Jard. Bot. Etat 20: 314 (1950).

Family Caesalpiniaceae (Leguminosae - Caesalpinioideae)

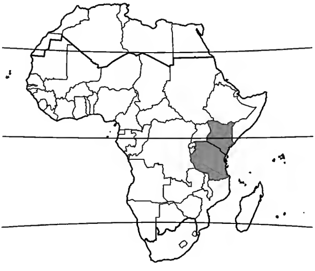
Synonyms *Berlinia magnistipulata* Harms (1922), *Isoberlinia magnistipulata* (Harms) Milne-Redh. (1937).

Vernacular names Mkwe, mkue, mukuwa (Sw).

Origin and geographic distribution *Julbernardia magnistipulata* only occurs in Kenya and Tanzania.

Uses The inner bark is locally used as tying material, for instance in construction. It is also used for weaving fish traps. In Kenya the wood is locally made into tool handles, spoons, stools, beds, construction poles and canoes. It is also suitable for heavy construction, furniture, joinery, doors and door frames. It is used as fuelwood and for charcoal making. The tree is a bee forage and also used for shade and ornamental purposes.

Properties The heartwood is reddish, darkening on exposure; the sapwood is pale yellow cream, turning red on exposure. The grain is usually crossed, but not interlocked. The wood has a density of 670 kg/m³. Seasoning is slow and should preferably be done in the shade. The wood is hard, with a modulus of rupture of 130 N/mm². It saws easily with little end



Julbernardia magnistipulata – wild

checking, and is very durable, being resistant to termites and marine borers.

Botany Evergreen, small to medium-sized tree up to 25 m tall, rarely a bush; bole up to 75 cm in diameter, buttressed; outer bark smooth, brown or grey; young branches glabrous. Leaves alternate, paripinnately compound with (1–)2–3 pairs of opposite leaflets; stipules intrapetiolar, 0.5–5 cm × 0.5–3 cm, connate at base, with 2 large, foliaceous lobes, persistent; petiole with rachis 4–9 cm long; leaflets elliptical, oblong-elliptical, obovate-elliptical or ovate-lanceolate, 6–11.5(–15) cm × 2.5–5(–8) cm, base cuneate, apex obtuse to acuminate, margin entire, glabrous (including margin), venation prominent on both surfaces. Inflorescence a terminal panicle up to 20 cm × 20 cm, brown-hairy. Flowers bisexual, 5-merous; pedicel 4–7 mm long; bracteoles 2, valvate, 8–9 mm × 8–9 mm, keeled on the back, persistent; sepals 5, (sub)orbicular, 3.5–5 mm × 3–4 mm, imbricate; petals 5, cream to white, 1 large and 4 small, the larger one suborbicular, 7 mm × 6 mm, shortly clawed, the others ovate or oblanceolate, 2–5 mm × 1–1.5 mm; stamens 10, 9 filaments shortly connate, 1 free; ovary superior, very shortly stipitate, style elongate, stigma capitate. Fruit an obovate-oblong or oblong pod 5.5–14 cm × 2.5–3.5(–5) cm, flattened, glabrescent, dehiscent into 2 woody valves. Seeds 1.5–2.5 cm × 1.5–2 cm, flattened, dark brown.

In Kenya *Julbernardia magnistipulata* flowers in August–October.

Julbernardia comprises about 10 species, all in tropical Africa. The bark of *Julbernardia unijugata* J.Léonard, an evergreen tree up to 18(–30) m tall only known from Tanzania, is used for making ropes and beehives, and the wood for tool handles, fuelwood and charcoal making. The tree also provides bee forage and shade. It is easily distinguished from other *Julbernardia* species by its leaves always having only one pair of leaflets.

Ecology *Julbernardia magnistipulata* occurs from sea level up to 1150 m altitude in lowland forest, riverine forest, coastal evergreen bushland, coastal *Brachystegia* woodland, and thickets.

Genetic resources and breeding *Julbernardia magnistipulata* is classified as vulnerable in the IUCN Red list of threatened species, due to its limited and declining area of occupancy. In the Arabuko-Sokoke Forest in eastern Kenya, for instance, the species only occurs in undisturbed parts and has completely disappeared from disturbed sites.

Prospects *Julbernardia magnistipulata* is a useful local source of fibre and timber, but in view of its limited distribution and declining occurrence, natural stands should be protected and unsustainable exploitation of the tree should be discouraged.

Major references Brenan, 1967a; Chikamai et al., undated; Lovett & Clarke, 1998; Lovett, Ruffo & Gereau, 2003; Pakia & Cooke, 2003a.

Other references Beentje, 1994b; Burgess, 2000; Missouri Botanical Garden, undated; Oyugi, Brown & Whelan, 2008.

Authors M. Brink

JUNCUS RIGIDUS Desf.

Protologue Fl. Atlant. 1: 312 (1798).

Family Juncaceae

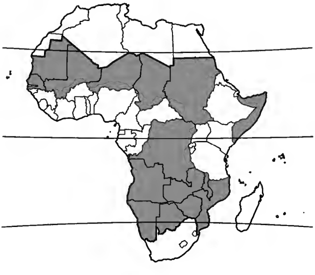
Chromosome number $2n = 46, 48$

Synonyms *Juncus maritimus* Lam. var. *arabicus* Asch. & Buchenau (1882), *Juncus maritimus* Lam. var. *rigidus* Desf. (1912), *Juncus arabicus* (Asch. & Buchenau) Adamson (1935), *Juncus nevskii* Krecz. & Gontsch. (1935).

Vernacular names Sea hard rush (En).

Origin and geographic distribution *Juncus rigidus* is distributed from the southern and eastern Mediterranean (including Sicily), southward to South Africa and eastward to Iran, Afghanistan and Pakistan. In tropical Africa it is distributed from Mauritania and Senegal eastward to Somalia, in DR Congo, and in all countries of southern Africa. It is not recorded from the Indian Ocean Islands.

Uses Since the Neolithic period *Juncus rigidus* and other *Juncus* species have been used



Juncus rigidus – *wild*

for thatching and for plaiting articles such as mats and baskets, for instance in Egypt. In ancient Egypt rush pens, most frequently made from the stems of *Juncus rigidus*, were used as writing implements as far back as the 3rd Century BC. In the Nile delta in Egypt small-scale cultivation of *Juncus* species for the production of mats was practised at the beginning of the 20th Century. In Tibesti (Niger) the stems are used for making brushes and sieves. The Tuareg in Niger are reported to eat the young shoots. *Juncus rigidus* is not grazed by domestic animals, except by camels, e.g. in Somalia. The seeds of *Juncus rigidus* and other *Juncus* species are employed in Asian traditional medicine as diuretic and a remedy for diarrhoea.

Production and international trade *Juncus rigidus* is only used and traded locally.

Properties Field experiments on saline soil in Egypt indicated that *Juncus rigidus* yields a suitable raw material for paper production, but commercial production was never realized.

Botany Robust, perennial, glabrous herb with an up to 10 mm thick, horizontal, woody rhizome, often laxly tufted by frequent rhizome forking; stems few to many, often set in dense rows, 50–150 cm long and 2–5 mm thick. Leaves basal, reduced to a bladeless sheath or 1–5 with leaf blades; sheath open; auricles absent; blade terete, 25–110 cm long, 1.5–3 mm thick, apex pungent, sclerenchymatous. Inflorescence composed of 1 or few sessile or subsessile panicles and 1–many stalked panicles bearing a variable number of usually few-flowered heads, 5–40 cm × 2–7 cm, lax, usually elongated, usually without any secondary branches in the axils of bracteoles; heads (20–)50–150(–300); lowest two bracts leaf-like, pungent, with wide sheaths, the first 5–25 cm long, including the 2–5 cm long sheath, the second bract 2–5 cm long, including the 1.5–3 cm long sheath, upper bracts small, bracts subtending heads much shorter than flowers, ovate, amplexicaul, cuspidate, straw-coloured; heads (1–)2–4(–6)-flowered, upper part of pedicel thick. Flowers bisexual; tepals 6, elliptical-lanceolate, 2–3 mm long, equal or outer ones slightly longer, pale brown to straw-coloured or when young greenish in centre, with broad, translucent, membranous margins, outer tepals narrowly ovate, boat-shaped, acute to obtuse, inner tepals oblong, obtuse; stamens 6, anthers 1–2.5 mm long, 3–6 times as long as filaments, yellow when young; ovary superior, 3-celled, style c. 1 mm long, stigmas 3, 1–1.5 mm long. Fruit a narrowly trigono-ovoid capsule 3.5–5 mm long, mostly conspicuously exceeding the tepals, apex tapering, trigonous, sometimes abruptly contracted, mucronate, usually pale brown to straw-coloured, 3-celled, 70–90-seeded. Seeds obliquely lanceolate, 1–2 mm long, 20–25-striate, reddish-brown, with prominent, pale, basal and apical appendages. Seedling with epigeal germination; first leaves very small, more or less U-shaped in cross section, 3rd and later leaves usually similar to adult ones.

Flowering is protogynous. Flowering starts early, well before the plant has reached its full adult height, which is usually reached after a few years. Early inflorescences are usually small.

The genus *Juncus* comprises 200–300 species of grass-like plants called rushes. They occur in wetlands all over the world, but are rarer in the tropics than more temperate regions. *Juncus* is divided into several subgenera; subgenus *Juncus* comprises 9 species occurring throughout the world. The species mentioned here are all classified in subgenus *Juncus*.

Juncus rigidus has often been confused with *Juncus maritimus* Lam., a related species with a more temperate distribution. It can be distinguished by its more obtuse capsule only slightly longer than the tepals.

Juncus acutus L. ('sharp rush') is a perennial, densely tufted rush with an extremely abbreviated, inconspicuous rhizome. It is distributed mainly in subtropical and warm temperate areas of Pacific and Atlantic Latin America and California, the islands of the Atlantic Ocean, including Cape Verde, North and South Africa and oceanic and southern Europe extending to Afghanistan and Pakistan, and in Australia and New Zealand. The stems are used for thatching and for making woven articles such as baskets and mats.

Juncus kraussii Hochst. is a perennial rush with a creeping, usually short-noded and densely branched rhizome, usually densely mat-forming. It is distributed in southern Africa, South America and Australia and is divided into 3 regionally separated subspecies. Subsp. *kraussii* ('salt-marsh rush') occurs in coastal South Africa, southern Mozambique and Madagascar, in both salt and fresh-water marshes, on river margins, rarely in maritime sand. Its stems are a favourite material in KwaZulu-Natal for making sleeping mats, including traditional bridal mats. They are also used for making water-tight baskets and household appliances. The species is locally heavily exploited, but in some places harvesting is well controlled through permits and the plant also grows in protected areas. It can be cultivated, also in freshwater rice fields.

Ecology *Juncus rigidus* typically occurs in maritime and inland, usually sandy, saline localities, from near sea-level up to 900 m altitude and up to nearly 2000 m in Katanga (DR Congo). It is found in Saharan oases, coastal sand-dunes, wadis, springs, depressions and other permanently or seasonally wet places in desert and steppe areas. In the Mediterranean part of its distribution it occurs in maritime localities, in Africa in inland localities. In coastal South Africa it is replaced by *Juncus kraussii.*

Management The seeds of *Juncus* species require constant moisture for at least several weeks to germinate. They germinate best when placed on the soil surface and in the light. When covered with a layer of sand or soil most seeds do not germinate. Seeds of *Juncus rigidus* germinate under saline conditions; in tests with a salt concentration of 3%, 80% of the seeds still germinated if the temperature was 10–20°C, while at 20–35°C, the same salt concentration totally inhibited germination. The germination rate of seeds harvested the same or the previous year is usually 95–100%. In a salt marsh in Egypt, the estimated net annual primary production was 21.5 t/ha.

Genetic resources and breeding *Juncus rigidus* is widespread and locally common and is not in danger of genetic erosion, but as a component of wetlands and oases in the Sahara desert it needs protection.

Prospects *Juncus rigidus* and other rush species are important sources of material for weaving and wickerwork and will remain an important resource for traditional handicrafts. Cultivation is easy and could be pursued to ascertain supplies. The role *Juncus rigidus* could play in the reclamation of saline land and in constructed wetlands for clearing polluted water deserves research attention.

Major references Burkill, 1995; Hepper, 1972; Lye, 1995b; Mansfeld, 1986; Snogerup, 1993.

Other references Alshammary, 2007; Lisowski, Malaisse & Symoens, 1973; Lymbery et al., 2006; Naidoo & Kift, 2006; Obermeyer, 1985; Perrier de la Bâthie, 1946; Sadek, 1996; Traynor, 2008; Traynor, Kotze & Mckean, 2010; van Wyk & Gericke, 2000; Zehran, 1979.

Authors L.P.A. Oyen

KNIPHOFIA PRINCEAE (A.Berger) Marais

Protologue Kew Bull. 28(3): 470 (1973).

Family Asphodelaceae (APG: Xanthorrhoeaceae - Asphodeloideae)

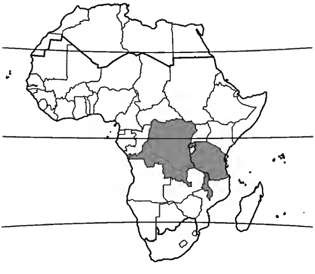
Vernacular names Red hot poker, torch lily (En).

Origin and geographic distribution *Kniphofia princeae* occurs in the mountains around Lake Kivu in DR Congo, Rwanda, southern Tanzania and northern Malawi.

Uses In Umalila (southern Tanzania) people use the leaves to make head-cushions for carrying loads. In Malawi strong cord is made from the leaf fibres. The flowers are sweet and sucked by children. They are also commonly visited by bees.

Production and international trade *Kniphofia princeae* is only used locally.

Botany Perennial, solitary herb 1.5–3 m tall; rhizome corm-like with short, well-spaced, erect, shoot-bearing branches; roots thick, fleshy, 2–3 mm in diameter, yellowish. Leaves in a basal rosette; blade lanceolate to linear, 115–200 cm × 2.5–3.5 cm, acuminate, margin toothed, strongly keeled, tough and fibrous, bright green. Inflorescence a lax to dense raceme 25–60 cm × 4–6.5 cm (1.8–3 m long including peduncle), elongating as the flowers open; peduncle 7–14 mm in diameter; bracts oblong to lanceolate, 5.5–11 mm × 1–2 mm, obtuse at the apex, with fimbriate-serrulate margins, brownish, persistent. Flowers red in bud, orange to bright red and yellow at the tips at anthesis, pendent, straight to slightly decurved; pedicel 3–6 mm long; perianth 25–38 mm long, constricted above the ovary into a long narrow tube 1–2 mm wide, then flared to



Kniphofia princeae – wild

5–7 mm wide at mouth, with 6 narrow lobes 2–4 mm long; stamens 6, unequal, level with the tube or slightly exserted, anthers blackish; filaments yellow; ovary sessile, ovoid, 3-celled, style filiform, exserted, up to 12 mm in older flowers, yellow, stigma minute. Fruit an ovoid to trigonous capsule c. 6 mm × c. 6 mm. Seeds ovoid.

In DR Congo flowering occurs between December and July, in the more southern part of its distribution area the flowering period appears to be more definite, from March to May.

Kniphofia comprises about 70 species mainly in southern tropical Africa, with 2 species in Madagascar and 1 in Yemen.

Ecology In DR Congo *Kniphofia princeae* is usually found in grassland, forest margins, or in humid shrubby vegetation near streams. It occurs in the open and under shade and has been recorded at altitudes of (1600–)1800–3450 m; in the more southern part of its distribution area up to 2700 m.

Management *Kniphofia princeae* can be propagated by seed or vegetatively through rhizome division. Planting at the beginning of the rainy season gives better results than planting later. Plants obtained through rhizome division flower much earlier than those grown from seed.

Genetic resources and breeding *Kniphofia princeae* is fairly widespread and locally common. There are no indications that it is in danger of genetic erosion.

Prospects *Kniphofia princeae* will probably remain of occasional local use only.

Major references Kativu, 2001; Marais, 1973; Latham, 2007; Whitehouse, 2002.

Other references Ramdhani, Barker & Baijnath, 2008.

Authors L.P.A. Oyen

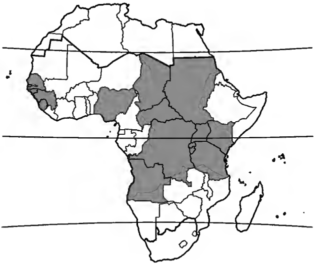
KOSTELETZKYA GRANTII (Mast.) Garcke

Protologue Linnaea 43: 53 (1880).

Family Malvaceae

Synonyms *Hibiscus grantii* Mast. (1868), *Kosteletzkya chevalieri* Hochr. (1906), *Hibiscus adenosiphon* Ulbr. (1917), *Hibiscus vilhenae* Cavaco (1954).

Origin and geographic distribution *Kosteletzkya grantii* is distributed from Senegal and Guinea Bissau eastward to Sudan and Kenya and southward to southern DR Congo and northern Angola.



Kosteletzkya grantii – wild

Uses The bark of *Kosteletzkya grantii* yields a long fibre used for making cordage. In DR Congo the leaves and fruits are reportedly eaten as vegetables, although they are covered with irritant hairs. In the Central African Republic a decoction of the root is believed to promote pregnancy. In Uganda the plant is used in the treatment of diarrhoea caused by food allergy.

Production and international trade *Kosteletzkya grantii* is only used and traded locally.

Properties The irritant hairs in dried leaves and fruits can cause damage to the eyes and choking. Leaves from Uganda had a crude protein content of 19.6 g per 100 g dry matter.

Botany Coarse, perennial herb or subshrub, erect or ascending, (0.5–)1–2.5(–3) m tall, with taproot or thickened, fibrous roots; stems with stiff, stellate hairs. Leaves alternate; stipules linear or linear-subulate, 5–12 mm long; petiole up to 5.5 cm long; blade ovate to orbicular, the lower ones mostly broadly transversely ovate, 4–12 cm × 2.5–11.5 cm, base cordate to truncate, lower and middle leaves mostly 3-lobed or 3-angular, apex acute to acuminate, margin with rounded or pointed teeth, upper surface rough, lower surface puberulent and more densely rough hairy. Inflorescences axillary or terminal glomerules or spike-like racemes with usually nearly sessile flowers. Flowers regular, bisexual; pedicel 1–7 mm long, densely short hairy; epicalyx broadly funnel-shaped, of 7–13 thin segments, unequal, 4–13 mm long; calyx funnel-shaped to cup-shaped, 6.5–9 mm long, with 5 triangular, pointed lobes; petals 5, obliquely obovate, 18–26 mm × 7–16 mm, pink, very rarely white; stamens merged into a 5-toothed column 12–21 mm long, anthers 25–40; ovary superior, 5-celled, style 5-branched, branches exserted, 1.5–4 mm long, pink, stigmas darker pink. Fruit a 5-celled, 5-angular capsule 8–9.5 mm in diameter, brown to yellowish brown, partly embraced by the slightly enlarged calyx, stellate and glandular hairy, valves 5, opening early, 1-seeded. Seed narrowly kidney-shaped to obovate, 3–4 mm long, brown, glabrous, with pale, slightly raised, concentric lines.

The genus *Kosteletzkya* comprises 17 species in tropical Africa, northern Latin America and the Philippines, and one species extending into temperate coastal areas of the United States, Europe and western Asia. They are characterized by a line of hairs running from one side of the leaf-base down to the node below it.

Kosteletzkya stellata Hutch. & Dalziel is also a good source of bast fibre. It is an erect or climbing shrub up to 4 m tall with 5-angled leaves and pink flowers about 2 cm in diameter; it occurs from Ghana to southern Nigeria.

Ecology *Kosteletzkya grantii* occurs at 400–2400 m altitude in grassland, open savanna, woodland, clearings and roadsides, and as a weed in pastures and cultivated fields. It grows on sandy and rocky soils.

Management Stems harvested for fibre are cut into 60 cm long pieces and the outer layers are scraped off. They are then retted for 2–3 days to release the fibre which is cleaned and dried.

Genetic resources and breeding *Kosteletzkya grantii* is widespread and sometimes weedy. There are no indications that it is at risk of genetic erosion.

Prospects Too little is known of the properties of the fibre of *Kosteletzkya grantii* to assess its prospects. It is recommended to evaluate the qualities of the fibre and the possibilities of growing *Kosteletzkya grantii* as a crop.

Major references Anokbonggo, Odoi-Adome & Oluju, 1990; Burkill, 1995; Friis & Vollesen, 1998; Verdcourt & Mwachala, 2009; Vergiat, 1970a.

Other references Chevalier, 1951; Hutchinson & Dalziel, 1928b; Irvine, 1961; Keay, 1958d; Rothman et al., 2006; Vergiat, 1970a.

Authors L.P.A. Oyen

KYLLINGA VAGINATA Lam.

Protologue Tabl. Encycl. 1: 148 (1791). Encycl. 3(2): 366 (1792).

Family Cyperaceae

Chromosome number $n = 9$

Synonyms *Kyllinga peruviana* Lam. (1792), *Cyperus peruvianus* (Lam.) F.N.Williams (1907).

Vernacular names Caribbean island spike sedge (En).

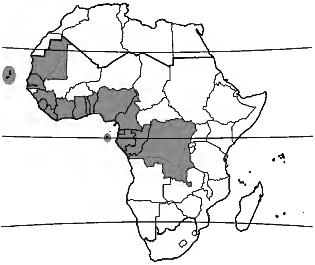
Origin and geographic distribution *Kyllinga vaginata* is distributed in West and Central Africa. It also occurs in Central and South America.

Uses In Senegal the plant is used for making mats. In Ghana it is used for stuffing mattresses. Outside Africa *Kyllinga vaginata* is planted as an ornamental.

Botany Perennial, glabrous herb with a 5–15 cm long rhizome covered with pink or reddish brown scales; stems in a row, erect, up to 40(–60) cm tall, obtusely 3-angled in cross-section. Leaves usually reduced to a reddish sheath, rarely with a well-developed blade. Inflorescence a terminal, solitary, dense, spherical spike 8–12 mm in diameter, whitish, with many, tightly packed spikelets; bracts 3, 0.5–1(–2) cm long, usually reflexed. Spikelets ellipsoidal, 2.5–4 mm long, with 2 flowers of which 1 sterile; glumes linear-lanceolate, 2–3 mm long, keeled, subacute at the apex, greenish white; fertile flower bisexual, perianth absent, ovary superior, 1-locular, stigmas 2. Fruit an obovoid nutlet 1–1.5 mm long, laterally flattened, dark brown, 1-seeded.

In Senegal *Kyllinga vaginata* flowers in (May–) July–December(–January).

Kyllinga comprises c. 60 species, distributed in



Kyllinga vaginata – wild

the tropical regions of the world. *Kyllinga polyphylla* Kunth (synonyms: *Kyllinga elatior* Kunth, *Cyperus pinguis* (C.B.Clarke) Mattf. & Kük.) is a perennial herb with stems up to 90 cm tall, distributed throughout tropical Africa. It is used for plaiting in Madagascar. A decoction of the aerial parts is taken in Madagascar for the treatment of fever.

Ecology *Kyllinga vaginata* is a slightly halophilous species occurring on coastal sands, in moist or inundated depressions in coastal dunes, tidal swamps, pools with brackish water, and fringes of mangroves, sometimes in populations of several square metres.

Management The 1000-seed weight is 0.19 g.

Genetic resources and breeding In view of its wide distribution *Kyllinga vaginata* seems not liable to genetic erosion.

Prospects *Kyllinga vaginata* is only occasionally used for plaiting and stuffing, and its importance is unlikely to increase.

Major references Akoègninou, van der Burg & van der Maesen, 2006; Burkill, 1985; Burkill, 2000; Simpson & Inglis, 2001; Vanden Berghen, 1988.

Other references Clarke, 1901–1902; Hoenselaar, Verdcourt & Beentje, 2010; Hooper & Napper, 1972; Lye, 1997a; Nelmes & Baldwin, 1952; Neuwinger, 2000; Roalson, 2008; Royal Botanic Gardens Kew, 2008b; Scholz & Scholz, 1983.

Authors M. Brink

LACCOSPERMA SECUNDIFLORUM (P.Beauv.) Küntze

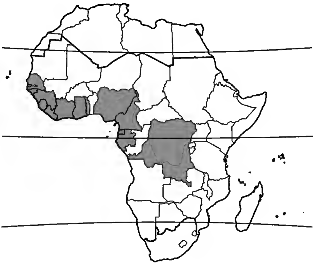
Protologue Rev. Gen. Pl. 2: 729 (1891).

Family Arecaceae (Palmae)

Synonyms *Calamus secundiflorus* P.Beauv. (1805), *Ancistrophyllum secundiflorum* (P.Beauv.) H.Wendl. (1878).

Vernacular names Large rattan, African climbing palm, African rattan palm (En). Palmier-asperge (Fr). Likaw (Sw).

Origin and geographic distribution *Laccosperma secundiflorum* is widely distributed in tropical Africa, from Senegal to DR Congo.



Laccosperma secundiflorum – wild

Uses The whole stems are mainly used for furniture framework, but also for binding and for walking sticks, baskets, fish-traps, suspension bridges and drumsticks. Thinner stems are used as rope. Split stems with the pith scraped out are used for basketry, fish-traps and as tying material. In Cote d'Ivoire the split stems are used in the fabrication of traditional drums by securing the goat-skin onto a wooden frame. Potential uses of the stem include the production of particle board and briquettes from waste material from furniture making. The leaves have been used as a thatching material in Sierra Leone, Ghana and Nigeria.

The apical bud (palm heart) is eaten, sometimes even raw. The young shoots are eaten boiled and fried as a vegetable. The soft pith of young shoots is also eaten. Sap from the stem is potable.

In Côte d'Ivoire women eat the boiled apical bud with the leaves of *Caesalpinia bonduc* (L.) Roxb. for the treatment of sterility-provoking stomach-ache. The soft pith of young shoots and a tea made from the young shoots are used against worms. In Cameroon an infusion of the leaves is taken against stomach-ache and dysmenorrhoea, the young shoots are a remedy against fever and dysentery and the sap is a vermifuge. In Cameroon and Congo the fresh stem is part of a preparation externally applied on dermatoses.

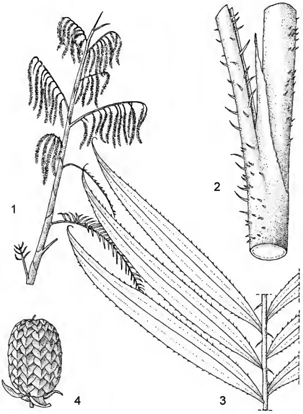
Production and international trade *Laccosperma secundiflorum* is important both at subsistence level and for commercial utilisation. Its unit of trade is the 'packet'. A packet of *Laccosperma secundiflorum* represents twenty stems, with each stem being 3–4 m long. The international rattan trade dates back as far as the 1920s, when Ghana supplied a significant proportion to the UK market. Some raw cane has been recently exported from Ghana and Nigeria to Korea. Currently, the international trade in rattan is worth about US$ 6.5 billion a year, but the international trade is dominated by South-East Asian countries.

Properties The stem is reddish brown and is of light to medium weight with a density of 400–600 kg/m^3 when oven-dry. It is valued because of its strength, durability, bending ability and aesthetic value. At 12% moisture content stems from Nigeria had a modulus of rupture of 91 N/mm^2 and a modulus of elasticity of 11,100 N/mm^2. It is common to see cracks on the stem surface. These cracks, which are areas of insipient structural failure, are attributed to different drying rates of the core and the outer portions. Furthermore, radial swelling and shrinking is higher than longitudinal swelling and shrinking, which may cause stresses within the cane leading to cracks and warping.

The stems are susceptible to discoloration by fungi, while beetles may make holes. The most common cause of staining are blue stain fungi. It is estimated that about 20% of harvested canes become stained if not treated. Fungal invasion can occur within one day of cutting. Staining can be controlled by spraying or soaking in preservative solution, but prophylactic treatment is seldom applied within 24 hours as required because of difficulties posed by harvesting procedures, storage and transport. Through intensive marketing, furniture in various colours has become fashionable. However, heavily stained material cannot be used for furniture since its bending strength is reduced; it is often utilized for baskets and other perishable products, or even as fuel. Poles can also be discoloured by surface moulds if transported or stored under humid conditions. Unlike blue stain, this discoloration is only superficial and can be wiped off. Nevertheless, the surface shine is reduced. At moisture levels of more than 20%, decay fungi can also attack the stem. Such infections are often noticed only at a later stage, when the fruit bodies appear, and they can cause serious structural degradation of rattan in service.

Air-dried samples of the stems in Nigeria were recorded to contain per 100 g: water 15.8 g, energy 1359 kJ (325 kcal), protein 2.9 g, fat 0.8 g, carbohydrate 79.4 g, ash 1.0 g, Ca 212 mg, Mg 35 mg.

Adulterations and substitutes The stems of *Laccosperma robustum* (Burret) J.Dransf. have roughly the same properties as those of *Laccosperma secundiflorum*, and can be used for the same purposes. In Ghana, small diameter bamboos are sometimes used to make cane furniture frames.



Laccosperma secundiflorum – 1, part of flowering plant; 2, part of stem; 3, part of leaf; 4, fruit.
Redrawn and adapted by Achmad Satiri Nurhaman

Description Moderately sized to robust, clustering rattan palm; stem 25–50 m long, 20–25 mm in diameter without sheaths, 30–35 mm in diameter with sheaths, internodes 10–50 cm long. Leaves sturdy, pinnately compound, up to 3.5(–5) m long; sheath dark green, armed with conspicuous brown to greenish sharp spines; ocrea 25–35 cm long and often torn at the margins, armed as sheath; petiole 20–60 cm long, rounded abaxially, concave adaxially, armed with black-tipped spines up to 18 mm long; rachis up to 1.5 m long, armed as petiole, distally prolonged into cirrus up to 2 m long, armed on the underside with black-tipped spines and bearing pairs of acanthophylls (leaflets modified into reflexed hooks) up to 4 cm long; leaflets up to 50 on each side of the rachis, elongate, often sigmoid but sometimes linear to lanceolate in shape, composed of 2–4 folds, 35–45(–60) cm × 2–8 cm, finely acuminate at the apex, dark green, margin armed with black-tipped spines 1–2 mm long. Inflorescence axillary, large, aggregate, branched to 2 orders; rachis branches 25–30 cm long, perpendicular to main axis; rachillae 15–20 cm long, pendulous; peduncle 15–20 cm long. Flowers bisexual, 2(–3) together, greenish white; calyx stalk-like at base, c. 8 mm long, with 3 triangular lobes c. 4.5 mm long; corolla c. 9 mm long, tubular at the base, with 3 valvate lobes; stamens 6; gynoecium 3-carpellate. Fruit ovoid, up to 2 cm × 1.5 cm, with 18–22 vertical rows of scales, reddish. Seed ovoid, 10–12 mm × 8–12 mm × 5–7 mm, often flattened on one side.

Other botanical information *Laccosperma* comprises 6 species and is restricted to Africa. Although most species can easily be distinguished using vegetative characters, different species may bear similar vernacular names. Hence misidentification is common.

Laccosperma acutiflorum (Becc.) J.Dransf. (synonym: *Ancistrophyllum acutiflorum* Becc.) is a robust rattan with stems up to 70 m long and 35–60 mm in diameter (45–80 mm with sheaths), distributed from Sierra Leone to Gabon and DR Congo. Its stem is reported to be of very poor quality and therefore it is only occasionally used.

Laccosperma laeve (G.Mann & H.Wendl.) H. Wendl. (synonym: *Calamus laevis* G.Mann & H.Wendl.) is an understorey rattan with stems 10–13 m long and up to 16 mm in diameter (up to 20 mm with sheaths), leaflets with spineless margins, and coffee bean-like seeds, distributed from Liberia to Cabinda (Angola). It is occasionally used for basketry or weaving, and in Gabon the pounded stems are woven into rope. The roasted root is eaten to improve virility.

Laccosperma opacum (G.Mann & H.Wendl.) Drude (synonym: *Ancistrophyllum opacum* (G. Mann & H.Wendl.) Drude) is an understorey rattan with stems 10–15 m long and up to 15 mm in diameter (20 mm with sheaths), globose fruits and warty seeds. It is distributed from Liberia to eastern DR Congo and perhaps Uganda. In Ghana the split stem is sometimes used for making baskets, and the leaves are used for thatching. Sap from cut stems is drunk, and the roasted palm heart is eaten. In Cameroon decoctions of the stems are used for the treatment of cough, rheumatism and fractures.

Laccosperma robustum (Burret) J.Dransf. (synonym: *Ancistrophyllum robustum* Burret) is a robust rattan with stems 30–45 m long and 30–50 mm in diameter (45–60 mm with sheaths), and pendulous leaflets. It is distributed from Nigeria to eastern DR Congo and Cabinda (Angola). The whole stem is used for furniture frames, and the split stems are used for coarse basketry. It is highly prized and much traded.

Anatomy The cross section of the stem shows three distinct regions: epidermis, cortex and central cylinder. The epidermis consists of a single layer of approximately square cells with a radial length of 11.6–19 μm and width of 8.7–14.5 μm. The cortex consists of fibre bands, rudimentary vascular bundles embedded in parenchyma cells, lying ring-like around the central cylinder. The cortex is 80–823 μm wide, with parenchyma cells round, oval and occasionally radially elongated, of varying sizes; intercellular spaces are present. There are two fibre rows just below the epidermis. The central cylinder is composed of vascular bundles embedded in ground parenchyma. The peripheral vascular bundles are larger and arranged in a patch-work-like manner; the inner ones are smaller and diffusely scattered. The vascular bundles consist of conducting tissue (xylem and phloem), surrounded by a fibre sheath and parenchyma. In a complete vascular bundle there is one metaxylem vessel with a diameter of 175–375 μm, the protoxylem consists of a cluster of 1–6 vessels, and the phloem occurs in a single field containing a cluster of 4–10 sieve tubes. The surrounding fibre sheath is more extensive in peripheral vascular bundles than in inner vascular bundles, which are horse shoe-shaped in cross-section. The fibre cells are 0.4–6.7 mm long and 7.3–43.5 μm wide, with a lumen width of 0.3–26 μm and a cell wall thickness of 2.9–37.7 μm. The ground tissue parenchyma, round to oval in shape and sometimes radially elongated (rectangular), is arranged in a net-like pattern.

Growth and development *Laccosperma secundiflorum* grows rapidly. In Cameroon an annual extension growth of about 2.8 m has been recorded for seedlings planted under obsolete rubber trees. Flowering is predominantly during the rainy season, and fruiting in the dry season. *Laccosperma secundiflorum* is hapaxanthic, which means that individual stems die after flowering. The seeds are dispersed primarily by birds (especially hornbills). However, primates, predominantly drills and mandrills (two species of forest primate related to the baboon), chimpanzees and gorillas are also key dispersal agents, as are elephants. Predation by rodents accounts for some additional dispersal.

Ecology *Laccosperma secundiflorum* occurs up to 1050 m altitude in high forest, rarely in secondary forest. It is particularly abundant in seasonally inundated and swampy areas. It grows well in poorly drained waterlogged soils in areas where the average annual rainfall is below 1600 mm. In areas with an average annual rainfall over 1750 mm, however, it prefers well-drained locations. The species prefers gaps in dense high forest, and it benefits from a certain amount of forest disturbance. The rootstock is easily killed by fire and it will not regenerate in areas that have been burnt several times in the past.

Propagation and planting *Laccosperma secundiflorum* can be propagated with seed or vegetatively using rhizomes or suckers. Seed propagation is more common since it is difficult to gather large quantities of suckers or rhizomes due to their bulkiness. However, seed germination is slow and seed mortality high. In trials in Cameroon emergence took as long as 100 days, with a germination rate of only 19%. This may be due to the seed having a relatively robust seed coat, which impedes imbibition, causing a dormancy that can delay germination for 9–12 months. In trials in Cameroon, the average time from planting to shoot emergence was 74 days for suckers and 84 days for rhizomes. In a trial in Côte d'Ivoire shoots emerged from suckers 35–56 days after planting, but shoots did not develop from rhizomes.

In-vitro propagation using axillary bud and apical meristem explants has proven possible, but for mass propagation the reliability and efficiency of the protocol need to be improved.

Management *Laccosperma secundiflorum* is harvested exclusively from the wild. Usually cutting of all the stems within a clump prevents juvenile ones from growing successfully, since their survival depends on the mature stems in the middle of the clumps. To ensure sustainability, only mature stems should be removed and adequate light should be made available to the juvenile ones to ensure vigorous regeneration. Where some level of management of wild *Laccosperma secundiflorum* is implemented, the cut stems are almost totally removed to deliberately allow adequate light penetration for regeneration of the clump. The same clump can then be harvested again 3–5 years later. Some clumps are known to have been harvested more than 4 times.

In on-farm trials in Ghana, Nigeria and Cameroon high post planting mortalities were recorded, which were attributed to neglect and predation by rodents. However, the growth rates reported in established plantings in West Africa were encouraging, which indicates that, once past the establishment phase, *Laccosperma secundiflorum* can be grown in a relatively short cropping cycle.

Diseases and pests *Laccosperma secundiflorum* is susceptible to attacks by fungi and insects due to its high starch content. Defects resulting from these attacks can result in severe losses.

Harvesting From each rattan clump, harvesters tend to cut only the mature canes; young stems are often left and can be harvested during a later visit. The stems selected are those with no lower leaves, and often only the lower 6 m (2 lengths of cane) are harvested. This is because living nodes form a considerable obstruction when the cane is split. So, the remaining 30 m of each mature stem is left in the canopy, and previously harvested rattan clumps are often marked by the presence of many dry stems in the canopy. The major disadvantage of this harvesting procedure is that, with the top sections of the cut stems remaining in place, there is little light penetration to the clump. This often means that the rhizome will not regenerate, and the clump often dies. In some communities improved harvesting is practiced, mainly with the aim of encouraging regeneration after harvest. In this case, the main part of the cut stems is removed from the canopy to allow sufficient light to reach the rhizome. Harvesting of rattans is often an unpleasant and dangerous occupation with dead branches being dislodged from the canopy, as well as ants and wasps being disturbed.

Yield *Laccosperma secundiflorum* and other rattans occur widely dispersed and therefore no reliable data on yield per unit area of forest are available.

Handling after harvest Freshly harvested canes should be treated shortly after harvesting, before transportation or usage, to reduce their weight and their susceptibility to attacks by fungi and insects. After being harvested, the stems are arranged into bundles and head-portered to local villages. Carrying these heavy bundles from far inside the forest makes for strenuous work. Afterwards, drying is undertaken in the open air with little or no preservative treatment. Other post-harvest treatments, including oil curing, bleaching, deglazing to remove the silicified epidermis and fumigation, are necessary to avoid defects and to increase processing possibilities and market value.

Genetic resources *Laccosperma secundiflorum* has a wide distribution and is not considered threatened, according to IUCN criteria. However, the demand for cane has increased over the years, and there is now a threat to the populations that are easily accessible.

Prospects The demand for *Laccosperma secundiflorum* is increasing, and in many parts of Africa much more is being processed today than five or ten years ago. The increased demand has led to a significant decline in wild stocks and considerable local scarcity, particularly around urban centres. Although the establishment of cultivation systems for the species seems useful for the rattan cottage industry in Africa, there appears to be little adoption among farmers, mainly because of land tenure issues and the relative abundance of rattans in the wild.

Major references Abbiw, 1990; Burkill, 1997; Defo, 2004; Ebanyenle & Oteng-Amoako, 2003; Oteng-Amoako & Obiri-Darko, 2002; Profizi, 1986b; Sunderland, 2007; Sunderland et al., 2005; Sunderland et al., 2008; Tuley, 1995.

Other references Abbiw, 1997; Adjanohoun et al. (Editors), 1988; Blach-Overgaard et al., 2010; Defo, 1999; Ebanyenle & Oteng-Amoako, 2005; Irvine, 1961; Jiofack et al., 2009; Kouakou et al., 2009a; Kouakou et al., 2009b; Kouassi et al., 2008; Lucas & Dahunsi, 2004; Mohanan, 1993; Morakinyo, 1995b; Olorunnisola, 2004; Olorunnisola, Pitman & Mansfield-William, 2005; Sunderland, 2001b; Sunderland et al., 2003; Tshiamala-Tshibangu et al., 1999; Vanden Berghen, 1988; Zoro Bi & Kouakou, 2004.

Sources of illustration Sunderland, 2001b.

Authors E. Opuni-Frimpong, L.K. Kwakye Ameyaw, E. Ebanyenle & T.C.H. Sunderland

LANDOLPHIA LETESTUI (Pellegr.) Pichon

Protologue Mem. Inst. Franç. Afr. Noire 35: 82 (1953).

Family Apocynaceae

Synonyms *Carpodinus letestui* Pellegr. (1898), *Clitandra letestui* Pellegr. (1925).

Origin and geographic distribution *Landolphia letestui* occurs from Cameroon and Gabon south to Congo and Bas Congo province in DR Congo.

Uses In Congo the stems are traditionally used for making ropes to climb palm trees.

Production and international trade Rope made of *Landolphia letestui* is only used occasionally and locally.

Botany Liana up to 15 m long; stem up to 10 cm in diameter; branchlets smooth or narrowly fissured, lenticellate, creamy or grey to dark brown, glabrous, latex white. Leaves opposite, simple and entire, with a long tendril in axil; petiole 3–12 mm long, glabrous; blade elliptical to obovate, 3–14 cm × 2–5 cm, base acute or sometimes rounded, sometimes decurrent, apex obtuse to acuminate, papery or leathery, glabrous. Inflorescence an axial or terminal, irregular, dichasial cyme 0.5–1.5 cm × 0.5–1.5 cm, up to 14-flowered; peduncle 1–3 mm long; bracts ovate or triangular, 0.5–1 mm × c. 0.5 mm. Flowers bisexual, 5-merous; pedicel 1–3 mm long; sepals unequal, ovate, 1–1.5 mm × 0.5–1.5 mm, connate at base; corolla tube 2–3 mm long, lobes equal or nearly so, ovate or elliptical, 1.5–3.5 mm × 1–1.5 mm, creamy, white or yellowish, sometimes discolourous; stamens inserted near middle of corolla tube, filaments c. 0.5 mm long, anthers acute; ovary superior, ovoid to rhomboid, 1–1.5 mm × 0.5–1 mm, pistil a head. Fruit ovoid, ellipsoid or obovoid, 3.5–6 cm × 3–6 cm, pale yellow, sometimes with orange-red gloss, 5–17-seeded. Seed irregularly ovoid, laterally compressed, 10–17 mm × 9–14 mm. Seedling with epigeal germination.

Landolphia letestui flowers from the beginning to the middle of the rainy season and fruits later in that season.

Landolphia comprises about 55 species occurring in Africa, Madagascar and the Mascarenes.

Ecology *Landolphia letestui* occurs from sea-level up to 500 m altitude in primary or secondary forest, in dense shade or in open places.

Management *Landolphia letestui* is only collected from the wild.

Genetic resources and breeding There is no information on the conservation status of *Landolphia letestui*.

Prospects *Landolphia letestui* is of occasional local use only, and there are no indications that the species will become more important in the future.

Major references Huber, 1963; Persoon et al., 1992; Pichon, 1953; Stapf, 1902–1904.

Other references Pauwels, 2002; Raponda-Walker & Sillans, 1961; Watson & Dallwitz, 1992–.

Authors L.P.A. Oyen

LANNEA SCHIMPERI (Hochst. ex A.Rich.) Engl.

Protologue Engl. & Prantl, Nat. Pflanzenfam. II–IV Nachtr. 1: 213 (1897).

Family Anacardiaceae

Synonyms *Odina schimperi* Hochst. ex A.Rich.

(1847).

Vernacular names Rusty-leaved lannea (En).

Origin and geographic distribution *Lannea schimperi* is distributed from Togo, northern Nigeria and Cameroon eastward to Ethiopia, and from Ethiopia southward through Kenya, Uganda, eastern DR Congo, Rwanda, Burundi, Tanzania and Malawi to Zimbabwe and Mozambique.

Uses In various areas the bark is used to make string and rope. The wood is occasionally used in carpentry, as fuel and is valued for charcoal production. The fruit is eaten fresh, e.g. by children in Nigeria during the rainy season and throughout East Africa. The seed is also eaten. The flowers are probably a source of nectar for honey bees. Branchlets and leaves are eaten by domestic animals.

A decoction of the stem bark is drunk, and the dried stem bark is smoked against backache and general weakness. The bark is also given as enema against dysentery and is applied to treat snake-bites. In western Tanzania the bark is used to treat opportunistic infections in AIDS patients, such as herpes, tuberculosis and diarrhoea. In Mozambique a decoction of the bark is drunk against stomach pain. Juice from the stem bark is given as enema to babies during feeding to avoid vomiting and diarrhoea. In the Nandi district in Kenya people take a decoction of the bark against diarrhoea, stomach pain and chest problems. A decoction of the roots is used as mouthwash against toothache, and is applied against chest troubles, colds and syphilis. The leaves, or leaf sap, are applied against bloody diarrhoea; leaf pulp is applied topically against vaginal prolapse. Unspecified parts are used in Tanzania to treat symptoms of diabetes mellitus. In Mozambique a decoction of the plant is drunk to treat cough. The fruit is taken against hookworm.

Properties The wood is white, lightweight (airdry density about 400 kg/m^3), soft and of little value as timber. The stem bark has shown antibacterial activity against *Staphylococcus aureus* and *Neisseria gonorrhoeae*; it is rich in anthocyanins and contains coumarins. The exudate is rich in the amino acid hydroxyproline. Unspecified parts have shown antifungal activity and a lowering effect on blood pressure.

Botany Small tree up to 10(–15) m tall; bole short, sometimes stunted and low-branching; outer bark grey to nearly black, smooth to rough, inner bark red with vertical orange streaks; crown spreading; branchlets stout and hairy, flower-bearing branches wrinkled. Leaves alternate, grouped at the end of branches, imparipinnately compound with 5–11(–13) leaflets; petiole and rachis 8–33 cm long, slightly grooved above, at first densely pinkish-rusty hairy, glabrescent; leaflets opposite, elliptical, oblong-ovate to ovate, 5–15.5 cm × 3–7.5 cm, basal ones somewhat shorter and broader, acute or obtuse at apex, terminal leaflet symmetrical, acute and on an up to 3.5 cm long petiolule, lateral leaflets sessile or on very short petiolule, asymmetrical, rounded, truncate or subcordate at the base, all at first densely pink-rusty tomentose on both surfaces; midrib fairly prominent beneath. Inflorescence a spike-like panicle, several crowded at the top of short branches, male ones up to 22 cm long, female ones up to 8 cm long, with hairy axis. Flowers in dense bundles; pedicel 1–3 mm long, tomentose; calyx-segments 4, c. 1.5 mm long, ovate to subcircular, ciliolate, stellate-hairy or almost glabrous; petals 4, 3.5–5 mm × 1.5–2.5 mm, oblong-ovate, greenish to bright yellow, fragrant; male flowers with 8 stamens inserted on cup-shaped disk and with rudimentary ovary; female flowers with short staminodes and ovoid to globose, 4-locular ovary of which 2–3 abortive. Fruit an obliquely ovoid drupe 7–10 mm × 4–6 mm, red. Seedling with epigeal germination; first leaves opposite and simple.

Leaves appear after the flowers and the fruits.

Lannea comprises about 40 species in tropical Africa and Asia. The related *Lannea zenkeri* Engl. & K.Krause is a large tree with a straight cylindrical bole, occurring in Gabon and Cameroon. Its bark is also used for making rope. The branches, which strike root easily, are used as pegs and marking posts. A decoction or maceration of bark chips which has been placed in the sun for some time is drunk against chest complaints.

Ecology *Lannea schimperi* occurs from sea level up to 2200 m altitude, in open forest, woodland and savanna.

Management *Lannea schimperi* only occurs wild.

Genetic resources and breeding *Lannea schimperi* is widespread and locally common, and there are no indications that it is threatened by genetic erosion.

Prospects *Lannea schimperi* is likely to remain a fibre plant of limited importance and occasional use only. Its value as a medicinal and fruit tree is also likely to remain of minor importance, although plant parts have shown antibacterial and antifungal activity and a lowering effect on blood pressure.

Major references Arbonnier, 2002; Burkill, 1985; Chhabra, Mahunnah & Mshiu, 1987; Kowaro, 1986; Neuwinger, 2000.

Other references Anderson, Howlett & McNab, 1987; Baerts & Lehmann, 2006; Chhabra, Uiso & Mshiu, 1984; Eggeling & Dale, 1951; Jeruto et al., 2008; Kisangau et al., 2007; Lockett & Grivetti, 2000; Moshi & Mbwambo, 2002; Raponda-Walker & Sillans, 1961; Van der Veen & Bodinga bwa Bodinga, undated.

Authors L.P.A. Oyen

LAPORTEA AESTUANS (L.) Chew

Protologue Gard. Bull. Sing. 21: 200 (1965).

Family Urticaceae

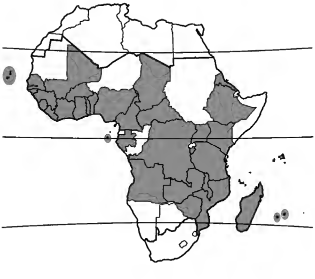
Synonyms *Fleurya aestuans* (L.) Gaudich. (1830), *Laportea bathiei* Leandri (1965).

Vernacular names Stinging nettle, West Indian nettle, West Indian woodnettle (En).

Origin and geographic distribution *Laportea aestuans* is widely distributed in tropical Africa, from Cape Verde eastward to Eritrea and southward to Angola, Zimbabwe and Mozambique, and in Madagascar. It also occurs in Yemen, tropical Asia and tropical America.

Uses The stem yields a fibre used for thread, string and rope. The slightly mucilaginous leaves are often eaten as a vegetable and in soup. The plant is a preferred food of the edible giant snail *Achatina achatina*.

Laportea aestuans is widely used in African traditional medicine. The pulped whole plant is eaten or the plant sap is drunk as an anthelmintic and for the treatment of hernia. Pulp of the whole plant is applied on the body in case of oedema and ulcers. The pulverized dried plant is rubbed into scarifications to cure headache and syphilitic yaws. A plant extract is drunk against cough or rubbed on the body to treat fever in children. Slightly scorched or smoked leaves are applied to burns and used against migraine. To treat gonorrhoea, the leaf is wrapped, roasted and ground in water, after which the liquid is drunk. In case of leucorrhoea, the leaf is ground in water and the liquid is drunk. Soup made from the leaf is considered good against indigestion. Boiled leaves are taken against constipation, but pounded with clay and water they are applied in enemas against dysentery. The pulverized leaf or leaf sap, mixed with palm oil or kaolin, is applied on abscesses and wounds, and on the head of children to close the fontanel. Leaf sap is rubbed on against toothache, and applied on the abdomen to ease childbirth. Liquid obtained by boiling the leaf is applied on swellings, and instilled in the eye to treat minor eye infections. A maceration of the fresh leaf is used to massage the body for the treatment of intercostal pain and stitches in the side. A leaf decoction is used against stomach-ache, as an embrocation to strengthen rachitic children and to relieve fever. An infusion of the leaf is taken for the treatment of filariasis, rheumatism and menopausal disorders. A decoction of the leaf and root is drunk as an antidote to any case of poisoning. The inflorescence mixed with the seed of *Aframomum melegueta* K.Schum. is eaten for the treatment of sore throat and hoarseness.



Laportea aestuans – *wild*

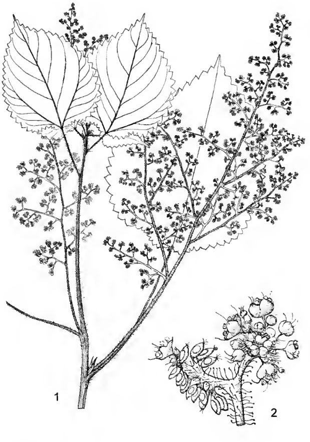
Properties The bark yields 45% fibre, which is irregularly distributed in the bark. The ultimate fibres are (15–)37–130(–252) µm wide, with an average cell wall thickness of 20 µm. The fibre is white and does not contain any lignin. The tensile strength is low. Degumming is moderately easy.

The fresh leaves contain per 100 g edible portion: water 80 g, energy 222 kJ (53 kcal), protein 5.8 g, fat 0.4 g, carbohydrate 10.0 g, fibre 3.0 g, Ca 440 mg, P 114 mg, Fe 1.5 mg (Leung, Busson & Jardin, 1968).

A methanol extract, before and after filtering through charcoal, and various fractions were assayed against 12 species of pathogenic bacteria and fungi. Extracts were active against 7 of them, especially *Staphylococcus aureus*. In subsequent phytochemical screenings, reactions were positive for steroids, but negative for alkaloids, flavonoids and anthraquinones. In another study a trace of alkaloid was detected in the plant.

Contact of the skin with the stinging hairs causes pain and blisters, but this effect is lost when plant parts are dried.

Description Annual, little-branched herb up to 1(–3) m tall; stem fleshy, slightly woody at base, densely covered with stinging hairs up to 1 mm long and soft glandular hairs 1–2(–3) mm long. Leaves alternate, restricted to the top of the stem, simple; stipules linear-lanceolate, fused for about half their length, up to 1 cm long, glabrous except for a few stinging hairs; petiole up to 16(–20) cm long, usually densely covered with soft glandular hairs, with a few stinging hairs intermixed; blade ovate to broadly ovate, (2–)6–20(–30) cm × (1–)3.5–15(–22) cm, base broadly cuneate to cordate, apex acute to acuminate, margin toothed, with on each side 30–40 teeth up to 5 mm long, chartaceous, upper surface with scattered stiff and stinging hairs and punctiform mineral concretions, lower surface with stinging hairs on the veins, lateral veins in 4–9 pairs. Inflorescence bisexual, rarely unisexual, paniculate, in the axils of upper leaves, up to 20(–40) cm long, covered with glandular and stinging hairs, with flowers in clusters c. 5 mm in diameter; peduncle 4–10 cm long. Flowers unisexual; male flowers scattered in the inflorescence and mixed with female ones or mostly at the base, 4–5-merous, pedicel c. 1 mm long, perianth 1–2 mm in diameter, usually with glandular hairs, soon falling; female flowers densely clustered, pedicel c. 0.5 mm long, tepals 4, unequal, the 2 lateral ones c. 0.5 mm long, the dorsal one half as long, the ventral one shorter, ovary superior, 1-celled, stigma filiform. Fruit an ovoid achene 1(–2) mm × 1(–2) mm, stipitate, laterally compressed, on each side with a ring enclosing a warted area, dispersed with the perianth.



Laportea aestuans – 1, flowering stem; 2, part of inflorescence.
Source: Flore analytique du Bénin

Other botanical information *Laportea* comprises 22 species, the majority of them in Africa and Madagascar. The bark of *Laportea amberana* (Baker) Leandri, a shrub up to 1.5 m tall endemic to Madagascar, also yields a good fibre.

Growth and development In Madagascar *Laportea aestuans* flowers in January–May.

Ecology *Laportea aestuans* occurs from near sea level up to 1300 m altitude, in farmland, along roads and in other disturbed locations in forest or woodland areas, always in partial shade, sometimes in rock crevices. It is very common, and is often considered a weed.

Diseases and pests In Costa Rica and Martinique *Laportea aestuans* was shown to be a host for root-knot nematodes (*Meloidogyne* spp.), which are pests in banana plantations. It is also a host of African cassava mosaic virus (ACMV).

Genetic resources In view of its widespread distribution and common occurrence, *Laportea aestuans* is not threatened by genetic erosion.

Prospects *Laportea aestuans* will continue to be of local use as a fibre plant, vegetable and medicinal plant, although the presence of stinging hairs makes handling of the plant difficult. In view of its wide application in traditional African medicine, it is an obvious candidate for pharmacological investigations, but so far remarkable little research has been carried out in this field.

Major references Adebajo, Aladesanmi & Oloke, 1991; Burkill, 2000; Chew, 1967; Friis, 1989c; Friis, 1991; Jacques-Félix & Rabéchault, 1948; Neuwinger, 2000; van Valkenburg, 2001.

Other references Adjanohoun et al., 1989; Ayensu, 1978; Boiteau, Boiteau & Allorge-Boiteau, 1999; Foco, Ndam & Fonge, 2009; Friis, 1989b; Hauman, 1948b; Jons, 2003; Kalanda & Omasombo, 1995; Keay, 1958i; Leandri, 1965; Letouzey, 1968; Leung, Busson & Jardin, 1968; López, 1982; Marais & Jellis,

1985; Medina, 1959; Otchoumou, N'Da & Kouassi, 2005; Pinto Basto, 2002; Quénéhervé et al., 2006; Raponda-Walker & Sillans, 1961; Williamson, 1955.

Sources of illustration Akoègninou, van der Burg & van der Maesen, 2006.

Authors M. Brink

LAPORTEA MOOREANA (Hiern) Chew

Protologue Gard. Bull. Sing. 21: 201 (1965).

Family Urticaceae

Synonyms *Fleurya mooreana* (Hiern) Rendle (1917).

Origin and geographic distribution *Laportea mooreana* is distributed from northern Nigeria eastward to Uganda and Tanzania, and southward to Angola, Zimbabwe and Mozambique.

Uses The plant yields a fibre which is used to make cordage and string in Cameroon. In the past *Laportea mooreana* was cultivated for its fibre on the Mambila plateau (Nigeria), in particular for the production of fishing nets. In DR Congo the boiled leaf is eaten as a relish, and the young leaf is cooked with bananas and eaten.

Properties Contact with the stinging hairs of the plant is painful.

Botany Annual, sparsely branched herb up to 1–2 m tall; stem more or less woody at base, hairy, frequently with stinging hairs 1–2 mm long on protuberances 1–2 mm high; outer bark usually pale, greenish to brownish. Leaves alternate, crowded towards the top of the stem, simple; stipules lanceolate, fused for about half their length, up to 1 cm long, with a few stiff hairs on the veins; petiole 1.5–15(–17) cm long, glabrous, but distal part usually densely covered with raised stinging hairs; blade broadly ovate to triangular, 4.5–20 cm × 3–18 cm, base truncate to almost cordate, apex acuminate to caudate, margin coarsely toothed, with on each side 8–18 teeth 6–15 mm × 6–15 mm, chartaceous, upper surface with scattered stinging hairs and punctiform mineral concretions, lower surface glabrous to hairy on the veins, on which raised stinging hairs frequently occur, lateral veins in 2–8 pairs. Inflorescence unisexual or bisexual, paniculate, solitary in the axils of upper leaves, up to 44 cm × 10 cm, with 10–20 side branches, axes often with raised stinging hairs; peduncle 2–5 cm long. Flowers unisexual; male flowers in separate inflorescences in the lower leaf axils or in the lower part of bisexual ones, 4-merous, pedicel c. 1 mm long, perianth 1–1.5 mm in diameter, sometimes with stinging hairs; female flowers in inflorescences in the upper leaf axils or in the upper part of lower inflorescences, pedicel c. 0.5 mm long, tepals 4, sometimes with 1 reduced, unequal, the lateral ones c. 1 mm long, the dorsal one slightly shorter, ovary superior, 1-celled, stigma linear. Fruit an ovoid achene 1–1.5 mm × 1 mm, sessile to slightly stipitate, laterally compressed, on the flattened sides with a ridge surrounding a warted depression, dispersed with the perianth.

Laportea comprises 22 species, the majority of them in Africa and Madagascar. Several species are used for their fibre, as vegetables, and in traditional medicine.

Ecology *Laportea mooreana* occurs at 900–1600 m altitude, in the undergrowth of rainforest, in riverine vegetation, on moist rocks in woodland or wooded grassland, and as a ruderal of waste places.

Genetic resources and breeding In view of its wide distribution and range of habitats, *Laportea mooreana* seems not threatened by genetic erosion.

Prospects *Laportea mooreana* will continue to be of local use as a fibre plant and vegetable. Detailed information on its properties is lacking, however, making it difficult to assess the prospects. The presence of stinging hairs makes handling of the plant difficult.

Major references Burkill, 2000; Chew, 1967; Friis, 1989c; Friis, 1991.

Other references Keay, 1958i; Letouzey, 1968; Terashima & Ichikawa, 2003.

Authors M. Brink

LEPIRONIA ARTICULATA (Retz.) Domin

Protologue Biblioth. Bot. 85: 486 (1915).

Family Cyperaceae

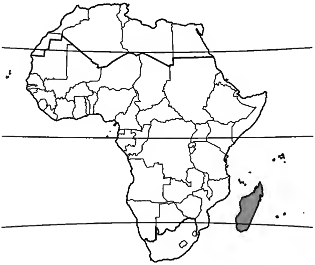
Chromosome number $2n = 34$

Synonyms *Restio articulatus* Retz. (1786), *Lepironia mucronata* Rich. (1805).

Vernacular names Tube sedge, grey rush, cigar rush (En).

Origin and geographic distribution *Lepironia articulata* occurs discontinuously from Madagascar through Sri Lanka, South-East and East Asia to Australia, the Caroline Islands, New Caledonia and Fiji. It is cultivated in Thailand, Sumatra, Borneo, India and China.

Uses In Madagascar and elsewhere the

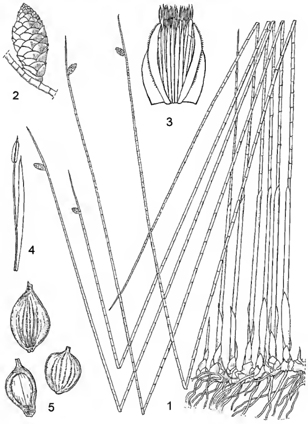


Lepironia articulata – wild

stems are used for weaving hats, mats, baskets and sacks. In Borneo and South Sumatra strong and completely closed *Lepironia articulata* mats have been used as packing material for tobacco, rubber, kapok, cotton, cane sugar and other products, for drying paddy and for the transport of food products such as rice, salt and dried fish. In China *Lepironia articulata* is used for making sails for junks. In Australia the still fleshy, thickened rhizomes are eaten by aboriginals. It is an ornamental pond plant.

Properties The stems of *Lepironia articulata* are very good weaving material, highly valued in Madagascar, because of its durability, suppleness and workability. In experiments the plant has shown potential for the phytoremediation of polluted water, especially as an accumulator of Pb.

Botany Perennial herb, often growing in large clumps; rhizome woody, creeping horizontally a few cm below the mud surface, up to about 15 cm × 0.5–1 cm, fleshy at first but becoming woody, many-noded, internodes about 1 cm long, dark brown, covered with brown, ovate-acute, striate scales and bearing numerous stout roots; stems close together, arranged in a row along the rhizome, each one erect, slender, cylindrical, 0.5–2.5(–3.5) m long, 2–8 mm in diameter, smooth and hollow but transversely septate (clearly visible when dried), glaucous or grey-green, clothed at the base with about 3 sheaths and 4–5 scales. Leaves reduced to bladeless sheaths, 3–30 cm long, upper one longest, split on one side, margins overlapping, brownish or reddish. Inflorescence consisting of a single spike-like cluster, apparently lateral owing to the single, erect, culm-like, involucral bract 2–7 cm long which extends the stem, gradually acute at apex; spike-like cluster ovoid-ellipsoid, 1–4 cm × 0.5–1.5 cm, purplish-brown, many-flowered; rachis thick, spongy, conical, persistent, bearing spirally arranged, tightly and densely imbricated, red-brown glumes; glumes ovate to obovate-orbicular, 3–7 mm × 3–6 mm, coriaceous with cartilaginous margin, glabrous, caducous with the fruit, each subtending a bisexual flower cluster (cyme) except some empty lower ones; each cyme with a terminal pistillate flower and up to c. 15 small, hyaline scales, each subtending a single male flower but the upper few often empty, the lowest pair opposite, folded, lanceolate, 4–6 mm × 0.5 mm, ciliolate on the keel, the remaining ones fascicled, linear-oblanceolate, 4–6 mm × 0.3 mm, acute, flat and glabrous; male flowers with only one stamen, anther linear, 2–3 mm long, shortly apiculate; female flower consisting of a naked pistil, style continuous with the ovary and ending in 2 long stigmas, its slightly thickened base persistent in fruit as a short beak 0.5 mm long. Fruit a double achene-like, strongly flattened obovoid



Lepironia articulata – 1, habit flowering plant cluster; 2, inflorescence; 3, flower cluster in axil of glume; 4, male flower in axil of scale; 5, three fruits.
Source: PROSEA

to subglobose nut 3–4 mm × 2–3 mm, longitudinally striate, brown, glabrous but margins scaberulous at the top.

Lepironia has often been considered a monotypic genus, with *Lepironia articulata* being the only species, but at present *Lepironia* and *Chorizandra* have been united into a larger genus *Lepironia*, with 1 species in subgenus *Lepironia* (characterized by an inflorescence consisting of one spike-like cluster and pistils with 2 stigmas), and 4 Australian species in subgenus *Chorizandra* (characterized by a head-like inflorescence with several spikes and pistils with 3 stigmas). Anatomically, *Lepironia articulata* can be distinguished from most other *Cyperaceae* by the stomata composed of 4 cells and the absence of silica bodies in the leaf epidermis cells.

Ecology *Lepironia articulata* occurs in shallow water (usually less than 0.8 m deep) in open swampy locations, open marshes, swamps in savanna-forests and along quiet streams, often near the coast. It grows in oligotrophic, slightly acid (pH 5.0–6.5) water. It often forms extensive communities. It is a weed of rice fields in Malaysia.

Management *Lepironia articulata* can be propagated by clump division. When harvesting the stems, cutting must preferably be done a few cm away from the rhizome because if the rhizome is damaged the plant will need more time to produce new stems. Total living biomass production (above and below ground) for *Lepironia articulata* in the Tasek Bera swamp in Peninsular Malaysia has been estimated at 2.2 g per m^2 per day. This is much lower than the biomass production of other tropical aquatic sedges, such as *Cyperus papyrus* L., which may be due to the low emergence rate of new stems in *Lepironia articulata*. In South-East Asia the harvested stems are dried for 3 days, after which they are tied into bundles 10 cm in diameter. These bundles are pounded with rice pestles until they are flat and ready for weaving.

Genetic resources and breeding In view of its wide distribution area, *Lepironia articulata* does not seem to be threatened with extinction. No germplasm collections or breeding programmes are known to be underway.

Prospects *Lepironia articulata* will remain a locally useful and readily available source of high-quality weaving material in Madagascar.

Major references Boiteau, Boiteau & Allorge-Boiteau, 1999; Brotonegoro, 2003b; Decary, 1946; Ikusima, 1978.

Other references Bryson & Carter, 2008; Dai et al. (Editors), 2010; Kern, 1974; Missouri Botanical Garden, undated; Rabarimanarivo, Jeannoda & Rabakonandrianina, 2005; Uchiyama et al., 2010; Wang, Cui & Dong, 2002.

Sources of illustration Brotonegoro, 2003b.

Authors M. Brink

Based on PROSEA 17: Fibre plants.

LINUM USITATISSIMUM L.

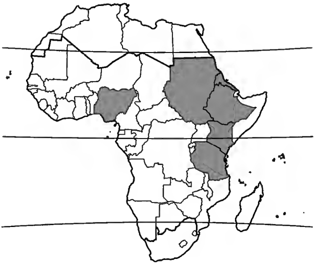
Protologue Sp. pl. 1: 277 (1753).

Family Linaceae

Chromosome number $2n = 30$

Vernacular names Linseed, flaxseed, flax (En). Lin (Fr). Linhaça, linho (Po). Kitani (Sw).

Origin and geographic distribution *Linum usitatissimum* most likely evolved by domestication from wild *Linum bienne* Mill. ('pale flax'), a short-lived perennial which occurs in western and southern Europe and western Asia. India is an important centre of genetic diversity for *Linum usitatissimum*, but cannot be considered the centre of origin because of the absence of its progenitor *Linum bienne*. *Linum usitatissimum* was among the first crops to be taken into cultivation in the Fertile Crescent more than 8000 years ago. It developed into a fibre crop, called 'fibre flax' and an oilseed crop, called 'linseed'. Archaeological evidence indicates that the domestication and early distribution of cultivated flax occurred principally as a fibre crop, but this may be due to the fact that textiles are more easily preserved than oil. Flax provided the fibres for cloth and cordage of the Sumerians, Egyptians, Greeks and Romans. It was traded by the



Linum usitatissimum – *planted*

Egyptians by 4000 BC and remnant seed has been found in prehistoric settlements in the Swiss Alps. The high oil content of the seed was also appreciated and Egyptian mummies provide evidence of the use of the oil by 1400 BC. Specialization occurred early: Mediterranean and European types developed into fibre flax; short-season types adapted to the warmer climates of western Asia, the Indian subcontinent and Ethiopia developed into linseed types.

Linum usitatissimum is now grown widely in many parts of the world, including the tropics. Fibre flax is cultivated in cool and humid temperate climates, whereas linseed is grown in warmer climates. Socio-economics also affect the distribution; Eastern Europe and the Russian Federation produce mainly fibre flax, Canada and the northern United States mainly linseed. In tropical Africa linseed production is concentrated in the Ethiopian highlands, where linseed has been grown since time immemorial. At higher altitudes it is the second most important oil crop after niger seed (*Guizotia abyssinica* (L.f.) Cass.). Linseed is also grown on a small scale in the other highlands of East Africa. Fibre flax has commercially been grown in Kenya and Uganda.

Uses *Linum usitatissimum* is grown for its oil-rich seeds and bast fibre, as distinct or dual purpose crops. There is a long tradition of consuming linseed, usually in a mix with cereals, in western Asia and the Indian subcontinent. In Europe and North America linseed is nowadays a standard ingredient in health foods such as multi-grain breakfast cereals and breads. In Ethiopia the seed is commonly roasted, ground and mixed with spices and some water to be served along with local breads. It is also consumed in soups, soft drinks and with porridges or cooked potatoes.

The oil develops a very unpleasant rancid flavour soon after seed crushing and oil extraction, making it less suitable for human consumption. This is associated with the high content of linolenic acid and rapid oxidation at the double bonds. Eventually, the oil polymerizes into a flexible film. Traditionally it has found wide application as drying oil in paints, varnish and industrial coatings, lamp oil and in the manufacture of window putty, soaps, printing ink, erasers and linoleum, as well as waterproofing for raincoats and tarpaulins. Edible linseed oil with only a few percent linolenic acid and much higher linoleic acid content is produced from 'Solin' or 'Linola' cultivar types recently developed in Canada and Australia. Seed mucilage is used as a substitute for gum arabic as a stabilizer, binder, gelling and suspension agent in foods. It has been patented as an egg-white substitute. Linseed cake and meal after oil extraction are used as a supplement of protein and omega-3 fatty acid in livestock feeds after prior removal of toxic substances. They are especially used to increase the omega-3 content of chicken egg and pork meat.

The traditionally highly valued medicinal properties of linseed have regained considerable interest in recent times. The seeds or their biologically active constituents (soluble and insoluble dietary fibre, α-linolenic acid and lignans) are used in nutraceuticals to alleviate various ailments, such as digestive complaints, high blood cholesterol, coronary and kidney diseases, hormonal problems and certain types of malignant tumours.

Linen woven from the bast fibre is used for household textiles (towels, table cloths etc.), furnishings (curtains, wall coverings and upholstery fabrics) and clothing. Its high moisture absorption, strength, launderability, excellent colour fastness and resistance to shrinkage make it well suited for these purposes. A disadvantage is that it creases easily. The fibre is also used in the manufacture of fine papers such as cigarette, art, currency, archival and security papers, often in blends with other pulps. The flax fibre used for paper is derived from waste material from spinning and weaving mills, linen rags, the short bast fibre fraction or waste product left over from the processing of high quality textile fibre ('flax tow'), or mechanically decorticated straw of flax that has been grown primarily for seed ('seed flax tow').

Straw from the linseed crop is also utilized in the manufacture of twine, bagging and insulating wallboards. The woody core left after fibre extraction is used in the manufacture of chipboard or, in combination with bast fibre, for paper making.

Production and international trade The average annual world production of linseed in 2004–2008 was about 2.2 million t from 2.5 million ha. The main producers were Canada (798,000 t), China (407,000 t), United States (268,000 t), India (174,000 t), Ethiopia (136,000 t) the Russian Federation (73,000 t), United Kingdom (48,000 t) and France (41,000 t). The average annual linseed exports in 2004–2008 were 987,000 t, with a value of US$ 429 million. Canada was the largest exporter of linseed (634,000 t/year), Belgium the largest importer (over 400,000 t) and the second largest exporter (138,000 t). Exports of linseed from tropical African countries were negligible.

The average annual world production of linseed oil was 648,000 t, with as main producers China (139,000 t/year), the United States (130,000 t) and Belgium (112,000 t). Ethiopia produced 46,000 t linseed oil per year. Annual world exports of linseed oil in 2004–2008 averaged 226,000 t, with a value of US$ 224 million. The main exporters were Belgium (89,000 t/year) and the United States (40,000 t), the main importers the Netherlands (43,000 t) and Germany (40,000 t).

The annual world production of flax (fibre and tow) in 2004–2008 was 730,000 t from 413,000 ha, major producers being China (460,000 t), France (93,000 t), the Russian Federation (50,000 t) and Belarus (47,000 t). The average annual flax (fibre and tow) exports in 2004–2008 amounted to 210,000 t, with a value of US$ 379 million. The principal exporters were France (94,000 t/year) and Belgium (63,000 t/year), the main importing countries China (89,000 t/year) and Belgium (32,000 t/year).

Properties The seed contains per 100 g edible portion: water 7 g, energy 2236 kJ (534 kcal), protein 18.3 g, fat 42.2 g, carbohydrate 28.9 g, total dietary fibre 27.3 g, Ca 255 mg, Mg 392 mg, P 642 mg, Fe 5.7 mg, Zn 4.3 mg, thiamin 1.6 mg, riboflavin 0.16 mg, niacin 3.08 mg, folate 87 µg, ascorbic acid 0.6 mg (USDA, 2011). The fatty acid composition of the oil in traditional linseed is: palmitic acid 5–6%, stearic acid 4–5%, oleic acid 18–20%, linoleic acid 14–16%, α-linolenic acid 40–60%. In the oil of 'Solin' and 'Linola' cultivar types, the linolenic acid levels can be as low as 2%, with a concomitant increase of linoleic acid, while the level of other fatty acids remains unaltered.

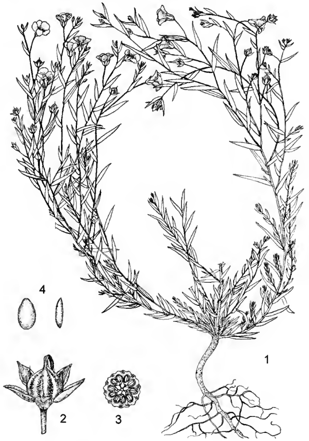
The mucilage of linseed consists mainly of soluble dietary fibre, which is composed of polysaccharides, polypeptides and glycoproteins. The ratio of soluble to insoluble dietary fibre in linseed varies from 1:4 to 2:3. The significant reduction in total and LDL cholesterol and in blood glucose associated with regular linseed consumption is attributed to the mucilage. Linseed also improves bowel movement: the mucilage absorbs water from the gastro-intestinal tract, while the insoluble fibre increases stool transit time. The α-linolenic acid is an essential, omega-3 fatty acid in the human diet. It is involved in increasing the activity of membrane-bound phospholipids, enhancing the elasticity of arterial membranes and reducing eicosenoids-mediated inflammatory reactions leading to arteriosclerosis and rheumatoid arthritis. Linseed is rich in plant lignans (diphenolic compounds), which are converted to mammalian lignans in the colon. Lignans inhibit cell proliferation and growth. They have been shown to be effective against hormone-sensitive cancers in particular.

The seed contains the cyanogenic glucoside linamarin, which in the presence of the endogenous enzyme linase (released after seed crushing) hydrolyses to form the poisonous hydrogen cyanide. Prior heating of the presscake avoids cyanide intoxication. The protein in the seedcake is low in lysine. Linseed cake and meal are said to have a regulatory effect on the digestive system of livestock, to increase the butterfat yield in dairy cows and to promote a shiny sheen in the coats of show animals.

Embedded within the cortex of the stem is a ring of 20–50 fibre bundles. Each of these bundles represents a single strand of commercial fibre. The proportion of fibre in the whole dry stem is influenced by both genotype and growing conditions and ranges from 28–36%. Each fibre bundle is made up of 10–40 fibre cells that are longitudinally interlocked and cemented to each other by pectins. The fibre cells are (1–)10–40(–100) mm long with a diameter of (5–)10–30(–40) µm and a narrow lumen. They are tapered at either end, round to polygonal in cross-section. The fibre cells of linseed genotypes tend to be shorter and coarser with a smaller lumen. The chemical properties of the fibre are: cellulose 60–85%, hemicellulose 9–19%. lignin 2–15% and pectin 0–9%. Flax fibre has a high moisture absorbency and is stronger than the fibre of cotton, rayon and wool, but weaker than ramie fibre. It is soft, lustrous and flexible, but not as flexible or elastic as cotton and wool fibres. The tensile strength, elongation at break, and Young's modulus of flax fibre are 345–1035 N/mm^2, 1.3–3.3% and 27,000–80,000 N/mm^2, respectively. The fibre cells in the xylem surrounding the pith and hollow central cavity of the plant have a mean length of 0.5 mm and a mean diameter of 16 µm.

Adulterations and substitutes Vegetable oils for human consumption can often be interchanged, blended or transesterified. In Ethiopia some linseed oil is blended with other high quality oils such as oil of niger seed, sunflower or safflower. Blending is done to minimize the formation of rancidity and so maintain an acceptable flavour. Safflower is also used instead of linseed to prepare a local dish called 'fit-fit' (a mixture of linseed flour, water and spices with local bread), which is often served during fasting seasons.

Description Erect annual herb up to 120 cm tall; root system consisting of a taproot with subsequent branching to a depth of up to 60 cm; stem slender, erect, glabrous, greyish green, often slenderly branched in the upper part. Leaves alternate to almost opposite in lower part of stem, alternate in upper part, simple and entire, sessile, without stipules; blade narrowly elliptical to linear or lanceolate, up to 50 mm × 5(–8) mm, glabrous, dull medium green, 3-veined from base to apex. Inflorescence a loose, terminal, leafy corymb. Flowers bisexual, regular, 5-merous; pedicel erect, 1–3.5 cm long; sepals free, broadly elliptical-ovate, 5–10 mm × 2–5 mm, acuminate; petals free, obovate, 8–15 mm × 4–11 mm, shortly clawed at base, margin slightly toothed, white to pale blue or purple-blue with hues of pink; stamens 5, united at base in a glandular ring, free part 2–6 mm long; styles 5, often shortly connate at base, 2–3 mm long, stigmas linear club-shaped, 1–2 mm long. Fruit a globose capsule 7–10 mm in diameter, 5-celled but often each cell divided by a secondary septum, up to 10-seeded. Seeds compressed, 6–10 mm × 2–3 mm, with indistinct, c. 1 mm long beak, glossy yellow to dark brown. Seedling with epigeal germination; hypocotyl 1.5–4 mm long, epicotyl up to 1.5 mm long; cotyledons elliptical-oblong, 6.5–14 mm long, leafy.



Linum usitatissimum – 1, plant habit; 2, young fruit; 3, young fruit in cross section; 4, seeds. Redrawn and adapted by Iskak Syamsudin

Other botanical information *Linum* comprises about 200 species. *Linum usitatissimum* is the only important crop, although a few species have ornamental value. *Linum usitatissimum* is highly variable and to classify this variability numerous subspecific groupings have been proposed. Two main groups are obvious: cultivars grown for the seed and those grown for the fibre. There is also a group of cultivars that are grown for both their seed and fibre. In all 3 groups numerous cultivars exist.

Changes in the nuclear DNA of certain flax cultivars can occur within a single generation due to specific environmental conditions. The characteristics altered include plant height, weight, number of branches and total nuclear DNA. These changes are not random events, but have been shown to occur repeatedly and to be inherited in the progeny.

Linum emirnense Bojer, a perennial herb up to 30 cm tall and *Linum betsiliense* Baker, a shrub up to 2 m tall, both endemic to Madagascar, also have fibrous stems. The former is used for making cushions to carry water vessels on the head, the latter can be used for weaving.

Growth and development Under tropical conditions, seeds germinate and emerge within 7–10 days after sowing. The first true leaves appear within 2–3 days after emergence. Early growth is slow under cool conditions. The taproot reaches 15 cm when the stem is 3–4 cm long. The taproot, and under dry soil conditions also lateral roots, of some cultivars may grow to a depth of 1 m. Branching is a cultivar characteristic; in some cultivars, e.g. from Ethiopia, branches are formed in the axils of the cotyledons or lower leaves; many linseed cultivars branch strongly from higher nodes, while fibre flax forms very few branches.

Fibre flax is a quantitative long-day plant, linseed is less photoperiod sensitive. Flowers open shortly after dawn and are predominantly self-pollinating. Pollination occurs round mid-morning. Some cross-pollination may occur depending on the population of insects, such as bees. The petals drop after pollination, with complete loss around midday. Stem length reaches its peak soon after flowering. Flowering is indeterminate, resulting in uneven formation of the capsules and subsequent maturation. As the capsules mature, they turn brown as the lower leaves and stem turn yellow. Seeds in the capsules become pale brown, plump and pliable, indicating maximum dry matter content. Seed ripeness is reached when the seeds are free and can be heard rattling inside the capsule.

Linseed cultivars produce about 60 leaves per plant, fibre flax cultivars about 80. Number of capsules per plant varies with genotype, management and climatic conditions but will typically range from 5–15 per plant. Total crop duration of linseed is normally 100–180 days, with 40–60 days from first flowering to harvest. For fibre flax the duration from sowing to harvesting is 90–120 days, to seed maturity 140–200 days.

Ecology Good seed yield can be achieved with a temperature range of 10–30°C, a midday relative humidity of 60–70%, and rainfall of 150–200 mm distributed over the 3-month growing period. Temperatures of –6°C may kill the crop in the seedling stage and frost may also cause injuries during the flowering and green capsule stages. Warm and dry conditions from early capsule development to maturity are required for curing the seed and for threshing. Rainfall towards maturity of the crop may cause secondary flowering and hence uneven maturity. Heavy rain and strong winds may cause lodging. In Ethiopia reasonable seed yields are obtained at 1600–2800 m altitude. In fibre flax hot dry days prior to and during flowering tend to cause branching resulting in shorter, more woody stems.

Optimum soils for flax are well drained but moisture retentive and medium to heavy textured, such as clay loams and silty clays. The soil should be of a fine tilth and not prone to crusting. Flax will not perform well on soils with pH less than 5 or above 7 and is sensitive to soil salinity.

Propagation and planting Flax is propagated by seed. The weight of 1000 seeds ranges from 4–13 g. Owing to the small seeds and poor competitiveness of the seedlings with weeds, a finely prepared, weed-free seedbed with adequate moisture is essential for successful crop establishment. Ploughing and harrowing or two or three passes with a traditional plough can do this. The seed may be broadcast by hand and then covered by dragging twigs of trees across the field. It can also be disked or harrowed but this may result in uneven sowing depth, emergence and maturation. Thus, sowing with a seed drill is preferred. The optimum sowing depth depends on soil type and moisture level. In heavy soils, 1.5 cm is usually enough, while on lighter soils, a depth of 2 cm reduces the risk of drought. On soils in which crusting occurs after heavy rain, making emergence difficult, a light harrowing is advisable. The seed rate depends on genotype, planting method, moisture conditions and objective of production. Higher seed rates are recommended for hand-sown crops and under high moisture conditions. Recommendations for linseed range from 17 kg/ha under low-rainfall conditions to 55–90 kg/ha under optimum water supply. Seed rates of 25 kg/ha are optimum for row-planted linseed in Ethiopia, with row spacing of 20 cm and a plant density of about 500 plants/m^2; for broadcasting seed rates of 35–40 kg/ha are recommended. For fibre flax a seed rate of 80–110 kg is recommended for optimum conditions when a seed drill is used; up to 150 kg/ha is recommended for hand-sown crops. Row spacings for fibre flax are 6–15 cm with a plant density of 1800–3300 plants/m^2. Seeds for planting should be free from weed seeds, shrivelled or diseased seeds and preferably treated with a fungicide.

Management Young linseed plants do not compete well with weeds and good weed control is necessary. This can be achieved by hand weeding twice (3 and 5 weeks after sowing) or with a range of pre- or post-emergence herbicides. Usually, early ploughing is practised to stimulate the germination of weed seeds, followed by shallow harrowing prior to sowing to kill the weeds. Water stress during flowering and early seed development negatively affects seed yield and quality, and where possible supplementary irrigation is recommended from budding until late grain filling. Later irrigation may lead to secondary flowering and uneven ripening. Linseed and fibre flax require relatively small amounts of nutrients though their uptake depends on soil type, cultivar and weather conditions. Typical uptake rates for a linseed or fibre flax crop yielding 5–6 t straw and 0.6–0.8 t seed per ha are approximately 50–75 kg N, 10–16 kg P, 40–60 kg K, 18–36 kg Ca and 8–11 kg Mg. In Ethiopia recommended rates of fertilizer for linseed are 23 kg N and 10 kg P per ha; average recommendations in the United States are 50 kg N, 25 kg P and 50 kg K per ha.

In fibre flax high N rates promote lodging, branching, lignification of the fibre and reduction of fibre wall thickness. Therefore, fibre flax never receives high rates of inorganic nitrogen and responds well to split applications. Ideally, the crop should draw most of its nitrogen from soil organic matter. Ample P is required for good seed yields and high-quality fibre, but excessive rates can result in reduced fibre quality. Sufficient K is essential for both fibre yield and seed quality. Organic manures are best applied to the preceding crop, as direct organic manuring may promote lodging and cause uneven growth.

Crop rotation is required for reducing weed infestation, disease development and improving organic matter of the soil. Flax should preferably not be grown in the same field more than once every 5–6 years and is best grown in a rotation that reduces weed infestation. It performs well after pulses, cereals and potatoes.

Diseases and pests The main diseases affecting linseed and fibre flax are caused by soil- or seed-borne fungi and can usually be controlled by seed dressing, rotation or use of disease resistant cultivars. The major seed-borne diseases are anthracnose (*Colletotrichum linicola*), grey mould (*Botrytis cinerea*), pasmo (*Septoria linicola*, anamorph *Mycosphaerella linicola*) and blight (*Alternaria* spp.). The symptoms of these diseases are stem or leaf lesions. Browning and stem break is a complex of symptoms caused by seed-borne *Polyspora lini* (synonym: *Aureobasidium lini*, teleomorph *Discosphaerina fulvida*). Early infection causes stems to break, infection at a later stage causes elongated brown lesions with purplish margins on the upper parts of the stem, giving heavily affected patches a brown appearance. The principal soil-borne diseases include stem rot (*Sclerotinia sclerotiorum*), wilt (*Fusarium oxysporum*) and scorch (*Pythium megalacanthum*). These diseases attack the root system or the lower part of the stem resulting in either lodging or the cessation of growth and gradual death of the plant from the top downwards. Another disease, rust (*Melampsora lini*), is characterized by the occurrence of bright red pustules (uredospores) on above-ground plant parts, later on replaced by black encrustations (teliospores). The spores are carried with the seed and on chaff fragments and can survive in the soil for up to two years. In infected areas, rust resistant cultivars should be used. It can also be controlled through seed dressing and crop rotation of 3–4 years. Powdery mildew (*Odium* spp.) is another fungal disease and its control is similar to rust. A recent survey showed that wilt, pasmo and powdery mildew are most prevalent in Ethiopia.

Linseed and flax attract a wide range of pests, but most are not considered to be of economic importance. Some may cause severe damage, however, if left unchecked: cutworms (*Agrotis* sp.) gnaw through young stems at ground level; red-legged earth mites (*Halotydeus destructor*) suck the sap from young seedlings resulting in low vigour and possible seedling death; various aphids cause damage through direct feeding or disease transmissions; sap-sucking thrips may retard growth and kill the plant; especially in Europe the larvae of flea beetles (*Aphthona euphorbiae* and *Longitarsus parvulus*) damage roots while the adults feed on leaves, stem and seed; in Canada potato aphid (*Macrosiphum euphorbiae*) became a pest of flax in the 1990s, while the caterpillars of *Heliothis* spp. penetrate the young capsules and cause substantial damage in Australian crops. Control is achieved either through the use of insecticides or by sowing the crop at a time of the year that is out of synchronization with the pest's life cycle.

Various birds may feed on young plants and remove the growing point, resulting in tillering and subsequent non-uniformity of maturation and a decline in yield. Bird control measures such as scarecrows, humming lines and gas guns, and a rapid establishment of the crop are recommended.

Harvesting The optimum time for harvesting linseed is when most capsules are fully mature and turn brown. At this stage, the seeds make a rattling sound in their capsule, while the stem and leaves turn yellow. The moisture content of the seeds will decrease to 10–15%. In Ethiopia harvesting is largely done manually by cutting the stems with a sickle. Some farmers harvest linseed by pulling the stems out of the ground to use them for making utensils, such as sweepers, baskets, etc. Threshing is done manually by beating the capsules with sticks or by oxen or horses trampling them on a well-prepared threshing floor. Then the seeds are separated from chaff by winnowing. In North America short-straw linseed is combine harvested when the seed is sufficiently dry (<10% moisture); under more humid conditions it is cut and swathed to dry before threshing.

The optimum time for harvesting fibre flax is when the leafy stems are green-yellow and the capsules are still forming, at which time the fibres are long and supple. Flax harvested too early and still green produces fine and weak fibres. Conversely, over-ripe, brown to dark brown flax yields brittle fibre with a high proportion of tow. Flax is typically pulled out of the ground rather than cut, to preserve the full length of the fibres. This is done by hand or with pulling machines, which pull and lay the crop on the ground in swathes. The capsules can be removed during pulling or left on the plant during retting and baling and removed in the processing factory. Threshing of the seed is usually done concurrently with 'scutching' of the fibre. Industrial flax or dual purpose crops are often combine harvested with conventional combine harvesters to avoid the cost of specialized pulling and turning equipment.

Yield World average seed yields of linseed in the period 2004–2008 were nearly 0.9 t/ha per year. In cool-temperate regions up to 2.0 t/ha is attainable with cultivars of 140–160 days duration. The yield potential of modern cultivars of linseed is estimated at about 3.0 t/ha. The average seed yield in Ethiopia is 0.7 t/ha, while improved cultivars with good management yielded up to 2.5 t/ha in favourable areas, such as Bekoji in the south-eastern part of the country. In Kenya yields of up to 2.3 t/ha have been achieved in experimental fields.

Average world flax (fibre and tow) yields have increased to about 1.5 t/ha per year; the highest yields being reported from Czech Republic (3.3 t/ha) and China (2.9 t/ha). In experiments in Australia stem yields of up to 8.8 t/ha, fibre yields of 1.3–2.6 t/ha and seed yields of 1.6–2.2 t/ha have been obtained.

Handling after harvest Threshing of linseed can be done about a fortnight after harvesting if dry and windy weather situations prevail; if not linseed plants are sun dried for up to 30 days. Seeds can be stored for a long period of time in clean containers under dry and well-aerated conditions. Optimum seed moisture for long-term storage is 9% or less. So far, no storage pests have been reported for linseed in Ethiopia. Traditional methods of oil extraction involve boiling of pounded and macerated seed in water and skimming off the floating oil. Small-scale oil extraction in rural areas has been made more efficient with the introduction of inexpensive screw presses, similar in design to the horizontal expellers of large oil mills, operated by hand or powered by a small diesel engine or electricity.

For fibre production retting is most commonly done in the field in a process called 'dew retting'. The duration and uniformity of dew retting depend on weather conditions. Ideally, harvesting needs to be followed by alternating periods of rain and dry weather; there must be sufficient moisture to ret the straw, but continuous rain can lead to over-retting and loss of fibre quality. To improve the uniformity of dew retting, it is necessary to turn the crop 3–4 times to expose the underside of the crop. When retting is complete and the crop is dry, it can be baled and stored. A range of off-field retting methods exist which are faster and provide greater uniformity of separation, but they are generally more expensive. Dried and retted stem material is 'broken', which involves rolling and/or crimping the stem to loosen the core from the bark. The core is then removed via a process known as 'scutching'. The separated bast fibre is 'hackled' by passing it through a series of combs of increasing fineness that scrape and buff the fibre. The end products are 'line flax', ready to be spun into yarn and 'tow' used in the manufacture of paper and other industrial applications.

Genetic resources *Linum usitatissimum* has been cultivated in many parts of the world and is very variable. Three distinct centres of diversity are recognized: the Mediterranean and western Asia, India and Ethiopia. Large germplasm collections are maintained in the main production countries: Biodiversity Conservation and Research Institute, Addis Ababa, Ethiopia (3110 accessions); Institute of Crop Germplasm Research (CAAS), Beijing, China (2556 accessions); Institute of Food and Oil Crops, Shijiazhuang, China (2165 accessions); Suceava Genebank, Suceava, Romania (4910 accessions) and the North Central Plant Introduction Station, Ames (IA), United States (2815 accessions). Important collections are also maintained in other countries in Europe. Preliminary collection and characterization of linseed has been underway in Ethiopia at Holetta Research Center since the early 1980s in collaboration with the Biodiversity Conservation and Research Institute. A recent analysis of the genetic diversity of 60 Ethiopian and exotic accessions, using morphological and molecular methods, revealed the presence of tremendous genetic diversity.

Breeding Breeding methods are those applied to self-pollinating crop species. Most linseed and flax cultivars grown today are pure lines developed by pedigree selection after crossing (and backcrossing) genotypes with contrasting characteristics. Breeding objectives for linseed focus primarily on seed yield and oil content. Breeding for seed quality is aimed largely at the fatty acid composition and has led to the development of low-linolenic acid cultivars in Australia and Canada. In cultivars developed for non-food purposes on the other hand, the linolenic acid content needs to be high. Breeding for disease resistance has resulted in cultivars that are resistant to Fusarium wilt and to rust. Breeding work in Ethiopia has concentrated on the development of disease resistance and all released cultivars are relatively resistant to wilt.

Well-known linseed cultivars include: 'AC-Emerson' and 'McDuff' (Canada), 'Verne 93' (United States) and the 'Solin' (low linolenic acid) cultivars 'CDC gold' and '2047'.

Some of the cultivars grown in Ethiopia are (with year of release): 'CI-1525' and 'CI-1652' (1984): medium to late maturing, good seed yield, high oil content, brown seed, blue flowers, tolerant to wilt, pasmo and powdery mildew; 'Chilalo' (1992): medium to early maturing, high yielding, medium oil content, brown seed, tolerant to wilt, pasmo and powdery mildew; 'Belay-96' (1996): similar to 'Chilalo' but with higher yield and oil content; 'Berene' (2001): similar to 'Chilalo' but adapted from mid to higher altitudes and with higher oil content; 'Tolle' (2004): medium maturing, high yielding, medium oil content, pale-brown seed, tolerant to wilt, pasmo and powdery mildew.

In fibre flax, breeders emphasize fibre content or fibre wealth (the ratio of fibre weight to total stem dry weight) more than fibre yield, as the latter is strongly influenced by management and environmental factors. Fibre quality is particularly important for flax grown for textile fibre. Important selection criteria for fibre quality are homogeneity, degree of lignification, strength, fineness and water uptake. Selection for industrial fibre flax may emphasize productivity rather than quality traits, given the normally negative correlation between these two traits. Substantial breeding efforts have been made to improve lodging resistance via straw stiffness and fibre content. Important fibre cultivars are: 'Ariane', 'Viking' and 'Viola' (France), 'Svetoch', 'Alexim' and 'Lenok' (Russia) and 'Heiya', a family of cultivars being developed in north-eastern China.

Various plant biotechnological techniques are finding useful application to supplement conventional linseed and flax breeding, such as in-vitro culture (explants, protoplasts, anthers, microspores), molecular marker-assisted selection, genomics and genetic transformation.

Prospects After a long period of stagnation of flax and linseed production, mainly due to the dominance of petroleum-based synthetic fibres and drying agents, the demand for the products of this crop has been growing rapidly in recent years due to a trend towards eco-friendly and natural raw materials. Linseed is also emerging as a major nutraceutical crop with a wide range of biologically active constituents present in the seed that promote health and may help prevent some important chronic diseases. World production of linseed and flax is expected to expand in the near future in response to increasing demands. Suitable conditions for profitable linseed production do exist in the highlands of East Africa.

Major references Adefris, Getinet & Tesfaye, 1992; Adugna & Labuschagne, 2002; Adugna & Labuschagne, 2004; Adugna, Labuschagne & Hugo, 2004; Lay & Dybing, 1989; Lisson, 2003; Luhs & Friedt, 1994; Morris, 2004; Muir & Westcott (Editors), 2003; Seegeler, 1983.

Other references Adugna & Labuschagne, 2003; Adugna & Labuschagne, 2005; Biagiotti, Puglia & Kenny, 2004; Boiteau, Boiteau & Allorge-Boiteau, 1999; Central Statistical Authority, 2001–2003; Chen & Thompson, 2003; Cui, 2001; Cullis, 2005; Decary, 1946; FAO, 2011; Fedeniuk & Biliaderis, 1994; Franck (Editor), 2005; Kirby, 1963; Leeson & Caston, 2004; Maggioni et al., 2002; Mwaikambo, 2006; Oh & Cullis, 2003; Payne, 2000; Perrier de la Bâthie, 1952; Riungu, 1990; USDA, 2011; Warrand et al., 2005a; Warrand et al., 2005b.

Sources of illustration Seegeler, 1983.

Authors W. Adugna

Based on PROSEA 17: Fibre plants.

LIVISTONA CARINENSIS (Chiov.) J.Dransf. & N.W.Uhl

Protologue Kew Bull. 38: 200 (1983).

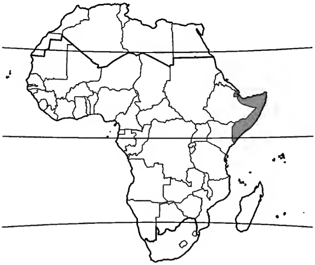
Family Arecaceae (Palmae)

Synonyms *Hyphaene carinensis* Chiov. (1929), *Wissmannia carinensis* (Chiov.) Burret (1943).

Vernacular names Bankoualé palm (En). Palmier de Bankoualé (Fr).

Origin and geographic distribution *Livistona carinensis* is distributed in Djibouti, Somalia and Yemen.

Uses In Djibouti the leaves are used for thatching. In Somalia the leaves of young plants are used for the production of mats and



Livistona carinensis – *wild*

baskets, and the stems for house building and drainage pipes. *Livistona carinensis* is sometimes the only source of straight timber locally available, and much sought after. The leaves are grazed by goats and cattle. A potential use of the species is as an avenue tree in dry locations.

Properties The wood is resistant to rot and termites.

Botany Large palm up to 40 m tall with solitary, unbranched, straight trunk with a diameter up to 40 cm, leaf scars prominent, petiole stubs persistent in the lower 1–2 m; crown globose to conical. Leaves up to 40 in the crown; leaf base with prominent, fine, persistent fibres, and with rigid, brown to black appendages 6–7 cm long on either side of the petiole; petiole up to 125 cm long, triangular in cross-section, armed with sharp, curved spines 7–25 mm long; blade almost circular in outline, 80–95 cm long, costapalmately divided for 75–85% of its length into 50–70 segments; segments with rigid apices, bifurcately cleft for 40–50% of the segment length, both surfaces waxy, glabrous; midvein prominent, 18–20 parallel veins at each side of the midvein. Inflorescence axillary, branched to 3 orders, arching, eventually pendulous, up to 240 cm long, extending beyond the crown by c. 20 cm, tomentose, pedunculate; branches very thin, yellowish, with scattered long hairs. Flowers in clusters of 5, bisexual, c. 2 mm long, yellow-green, perianth segments with scattered long hairs outside; sepals 3, triangular; petals 3, free, triangular, longer than sepals; stamens 6, inserted on the petals, filaments united into a fleshy ring, anthers medifixed; ovary of 3 carpels, united above to form a single style. Fruit globose, 5–20(–50) mm in diameter, dark brown to black, glabrous, with terminal stigmatic remains. Seed globose.

Livistona comprises about 28 species, with only *Livistona carinensis* present in tropical Africa, and the rest of the genus distributed from north-eastern India through Indo-China and South-East Asia to Australia.

In Djibouti growth rates of adult *Livistona carinensis* measured over a 13-year period were 17–33 cm per year, and a palm 16.9 m tall was estimated to be 93 years old. Natural regeneration is by seed and suckers.

Ecology *Livistona carinensis* occurs in or near streams and springs in areas with an average rainfall less than 450 mm, in Djibouti at 600–1000 m altitude, in Somalia at 200–1100 m altitude, and in Yemen at 200–450 m altitude.

Management Seeds germinate within 2–3 months after sowing.

Genetic resources and breeding *Livistona carinensis* is classified as vulnerable in the IUCN Red list, because of its limited occurrence. Recently it has been proposed to upgrade its status to endangered. In Djibouti about 300 adult trees were counted in 2006 and the species faces a lot of pressure from habitat loss, grazing, flash floods and overharvesting of the leaves for thatching. In Somalia only 38 trees in 2 localities were known in 1998; regeneration is prevented by grazing and exploitation of the leaves of young plants for weaving. In Yemen there are about 2000 trees in 3 villages; major threats are grazing by goats and local over-harvesting of the wood as timber. A conservation plan for the species has been developed in Djibouti, but in Somalia and Yemen there are no active conservation programmes. Populations have been established in several botanic gardens and private collections, in the hope of saving the species in cultivation. The genetic diversity within the species is low, particularly among the Djibouti populations.

Prospects In view of the vulnerability of the species, in-situ conservation of existing stands should have a high priority. Necessary measures include the protection of seedlings from grazing, harvesting and flooding, and the supplementation of existing populations with seedlings propagated by man. The creation of new populations may be essential for the survival of the species.

Major references Barbier, 1985; Dowe, 2009; Ford et al., 2008; Shapcott, Dowe & Ford, 2009;

Thulin, 1995a.

Other references Bazara et al., 1990; Dransfield & Uhl, 1983; Ford & Bealey, 2004; Johnson, 1998c; Kiambi, 1999; Lucas & Synge, 1978; SEPASAL, 2010e.

Authors M. Brink

LODOICEA MALDIVICA (J.F.Gmel.) Pers.

Protologue Syn. Pl. 2: 630 (1807).

Family Arecaceae (Palmae)

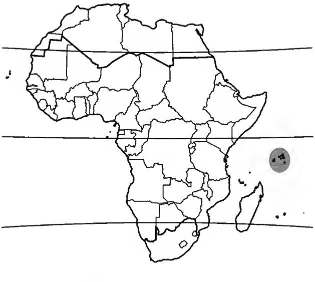
Chromosome number $2n = 34, 36$

Synonyms *Cocos maldivica* J.F.Gmel. (1791), *Lodoicea callipyge* Comm. ex J.St.-Hil. (1805), *Lodoicea sechellarum* Labill. (1807).

Vernacular names Double coconut palm, sea coconut palm, coconut of the Maldives (En). Coco-fesses, coco de mer, cocotier de mer, cocotier des îles Seychelles, cocotier des Maldives (Fr). Coco do mar, coco das Maldivas (Po).

Origin and geographic distribution *Lodoicea maldivica* is endemic to the Seychelles, where natural populations exist on the islands of Praslin and Curieuse. It is cultivated in the Seychelles and elsewhere, for instance in coastal towns in East Africa and in India. Long before the palm was discovered on the Seychelles, the empty fruits and shells were already known on the costs of India and the Maldives, as they float in water and are transported by ocean currents. The palm itself did not spread overseas, as viable seeds are too heavy to float.

Uses The young leaves are used for plaiting mats, hats and baskets, while the old leaves are used for thatching. Down from young leaves is used for stuffing. The wood is used for making palisades and water troughs. The terminal bud (palm heart) is eaten as a vegetable, also after being preserved in vinegar. The bilobed stones (endocarp with seeds) are collectors' items because of their size and shape. The shells (endocarp) are used as water vessels, bowls and plates. The endosperm is eaten, e.g. in soups in China. It is credited to be aphrodisiac and an antidote for poisons. The palm is grown as an ornamental in many parts of the tropics.



Lodoicea maldivica – wild

Production and international trade After the discovery of the palm on Praslin in 1768, the stones (often called seeds or nuts) were shipped in large quantities to eastern markets. Nowadays they are sold to tourists, which is locally an important source of revenue. In 1997 about 1600 stones were collected, in 1998 about 1500. They are sold at prices of € 190–450, depending on size and symmetry. Stones sold to tourists require an official export permit.

Properties The fruit is very heavy, with a weight of c. 20 kg, and it contains the largest seed in the plant world, weighing up to 16 kg. The powdered fruit has shown hypoglycaemic and antihyperlipidemic effects in humans and rabbits.

Botany Dioecious palm up to 30 m tall, unarmed; stem erect, up to 25 cm in diameter. Leaves up to 12 in crown; sheath splitting opposite the petiole; petiole robust, 3–6(–10) m long, deeply channeled above, rounded and black-dotted below, margin of basal part fibrous; blade 3–5 m × 2–3 m, costapalmately divided for 25–35% of its length into segments, base wedge-shaped; segments linear-lanceolate, single-fold, shortly bifid, stiff, upper surface shiny and smooth, lower surface dull, midvein prominent below. Inflorescence between the leaves, up to 2 m long, pendulous, enclosed in 2 bracts; male inflorescence with short peduncle terminating in 1–3 catkin-like rachillae with pits each containing 60–70 flowers; female inflorescence unbranched, rachilla a direct extension of and about as long as peduncle, zigzag, bearing sheathing bracts each subtending a flower, 5–13-flowered. Flowers unisexual; male flowers with fibrous bracteole, sepals 3, connate, corolla with long stalk-like base and 3 lobes, stamens 17–22; female flowers 5 cm wide, sessile, ovoid, bracteoles 2, sepals 3, petals 3, staminodes triangular, gynoecium 3-celled, stigmas 3. Fruit an ovoid drupe up to 50 cm long, olive green, 1(–3)-seeded; exocarp smooth; mesocarp fibrous ('husk'); endocarp ('shell') comprising 1(–3) bilobed pyrenes ('stones'). Seed c. 30 cm × 28 cm, 2-lobed.

Lodoicea maldivica is the only species in the genus *Lodoicea*.

Germination takes about 1 year. After germination, the cotyledonary stalk first buries to a depth of 30–60 cm and then extends horizontally for up to 10 m, resulting in the seedling becoming established some distance from the seed itself. In the juvenile phase, which may last 2–60 years, the palm is trunkless. During the juvenile phase about 20 leaves are produced from the buried stem apex. Subsequent leaves are produced from the developing trunk at intervals of 9 months, and live for about 9 years after expanding. Flowering starts when the trunk is about 4 m tall. Pollination is probably by insects. The fruit takes 4–7 years to mature. In natural stands mature female trees typically bear 2–9 fruits at any one time, while cultivated trees can bear as many as 60 fruits. Trees may live for about 350 years and reproduce for about 300 years, but male trees live longer than female ones.

Ecology The island of Praslin, home of the largest natural population of *Lodoicea maldivica*, has an average annual rainfall of about 1600 mm, with the mean monthly rainfall exceeding 100 mm except in June, July and August. The mean monthly temperatures at sea level are 24–26°C.

Management After harvesting the endosperm is removed from the stone and the empty shells are reassembled for sale.

Genetic resources and breeding *Lodoicea maldivica* is classified as vulnerable in the IUCN Red list of threatened species, the major threats being overexploitation of the fruits and fire. The species is now protected and the trade in stones is legally controlled by the 'Coco-de-mer Management Decree' of 1995. Natural stands are preserved in reserves on the island Praslin. In 1997 the largest population, in the Vallée de Mai reserve, consisted of 1162 mature trees, of which 45% were female. Because most stones are removed for sale to cover management costs and illegal harvesting also occurs, regeneration levels are too low. *Lodoicea maldivica* in the Seychelles is listed in CITES Appendix III, which means that international trade in its stones is allowed only on presentation of the appropriate permits or certificates.

Prospects *Lodoicea maldivica* is a popular species for its characteristics stones, but it only occurs in few locations and is threatened by overexploitation of the fruits, endangering regeneration. Appropriate harvesting protocols are necessary to ensure the future of the remaining natural populations.

Major references Edwards, Kollmann & Fleischmann, 2002; Purseglove, 1972; Rist et al., 2010; Robertson, 1989; Uhl & Dransfield, 1987.

Other references Akhtar et al., 2009; Dransfield, 1986; Fleischmann et al., 2005; Gerlach, 2003; Hanelt & Institute of Plant Genetics and Crop Plant Research (Editors), 2001; Henderson, 2002; Huxley (Editor), 1992c; Nature Protection Trust of Seychelles, 1998; Rouillard & Guého, 2000; Swabey, 1970.

Authors M. Brink

LOESENERIELLA AFRICANA (Willd.) N.Hallé

Protologue Thèses Fac. Sci. Univ. Paris, Monogr. Afr. Occ.: 99 (1958).

Family Celastraceae (Hippocrateaceae)

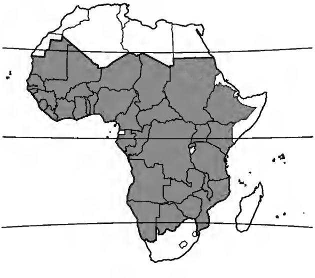
Chromosome number $2n = 56$

Synonyms *Hippocratea richardiana* Cambess. ex St.-Hil. (1899), *Hippocratea africana* (Willd.) Loes. (1910).

Vernacular names African paddle-pod (En).

Origin and geographic distribution *Loeseneriella africana* is very widespread in continental tropical Africa and is also found in South Africa, India, Sri Lanka, Myanmar and Laos.

Uses The split stems of *Loeseneriella africana* are widely used for tying in roof construction and in other building activities. In Ethiopia the stems are used for tying in the construction of bee hives and granaries and for weaving baskets. In Kenya the stems are used for making baskets for sifting grain, and in



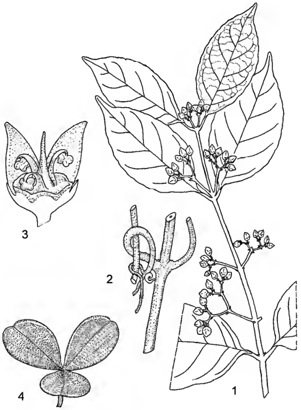
Loeseneriella africana – wild

Kenya and Tanzania the bark is used for making rope. In Côte d'Ivoire the stems are used as chew-sticks to clean the teeth. The wood is used in Burkina Faso for making tools and handicrafts.

In traditional medicine in Senegal an infusion of dried leaves is drunk as a remedy for colds and a decoction of the whole plant is drunk to treat oedema. In Côte d'Ivoire the powdered leaves are taken in case of menstrual pains. In Burkina Faso a decoction of the leaves is used to treat children suffering from malaria or an inflammation of the spleen. In Togo ailing babies are given a decoction of the leafy twigs and in Benin a tonic is prepared from the leaves for newborns. In Nigeria a root extract is used as a cure for malaria and for the treatment of skin-infections. In the Central African Republic a patient's body is washed with a leaf decoction to bring down fever. In DR Congo spreading, obstinate ulcers are treated with leaf preparations. In Malawi and Zimbabwe an infusion of the roots is taken by mouth as an aphrodisiac and also to cure abdominal pains.

Properties The stems of *Loeseneriella africana* are tough, flexible, durable and resistant to termites, and they are therefore in high demand. The fruits are poisonous. Laboratory tests have revealed no significant activity against fungi and gram-positive or -negative bacteria. Ethanolic extracts of the roots have shown analgesic, anti-inflammatory and antipyretic properties in mice and rats, and antiplasmodial activity in mice infected with *Plasmodium berghei*. Extracts of the leaves made with methanol and dichloromethane did not show significant activity in vitro against *Plasmodium falciparum*.

Description In closed vegetation usually a tall liana up to 15 m long, sometimes longer, in exposed situations a bushy or scandent shrub c. 2 m tall with densely branched crown; stem grooved, up to 10 cm in diameter; bark smooth and dark brown to purplish red, cracked in old plants; old branches terete, grey to brown, often with lenticels, sometimes with tendrils. Leaves opposite, simple, very variable in size and colour; stipules hairy, pointed, caducous; petiole 3–10 mm long; blade elliptical, 2–15 cm long, subacute to rounded at base, shortly acuminate or sometimes obtuse at apex, margin entire or toothed, shiny above, with 4–9 pairs of secondary veins. Inflorescence an axillary, regularly dichasial cyme 1–2.5 cm long, usually soft-hairy, several–many-flowered; peduncle 5–15 mm long. Flowers bisexual, regular, urn-shaped or flattened, 10–14 mm in diameter, green; pedicel 1–2.5 mm long; sepals 5, subequal, ovate to semiorbicular, with ciliolate margin; petals 5, free, triangular, 4–5 mm × 2 mm, free or attached to the disk, glabrous or short hairy on the outside; disk a basal cup with androgynophore of c. 6 mm long; stamens 3, fused to base of the disk, filaments white, anthers orange-red; ovary just below insertion of stamens, 3-celled, style c. 1.5 mm. Fruit of 3 dehiscent, flat, obovoid-oblong mericarps, each mericarp 6–9.5(–12) cm × 3–4 cm and 6–9-seeded. Seeds 3–4.5 cm long, with an ovate or oblong wing with marginal and median vein. Seedling with hypogeal germination.



Loeseneriella africana – 1, flowering branch; 2, part of stem with tendril; 3, flower with 3 petals removed; 4, fruit.
Source: Flore analytique du Bénin

Other botanical information *Loeseneriella africana* is a polymorphic species and as a result many infraspecific taxa have been described. At present 4 varieties are recognized.

The Old World genus *Loeseneriella* comprises about 16 species. Apart from *Loeseneriella africana* several other species of the genus are used for their fibres.

Loeseneriella clematoides (Loes.) N.Hallé is a very tall liana with stems 40–100 m long. It is distributed from Guinea eastward to Uganda (but absent in Togo and Benin) and extending southward to Angola. In Gabon the stems are used for making hanging bridges. In DR Congo the bark is harvested from the wild and liquid from the bark is used as nose-drops to treat children with fever. The unsustainable harvesting of the bark has made it a scarce species at least in parts of DR Congo. The leaves are eaten as a vegetable. Edible 'minsindu' caterpillars feed on the plants.

Loeseneriella rowlandii (Loes.) N.Hallé (synonym: *Hippocratea rowlandii* Loes.) is a liana with stems up to 50 m long, distributed in Guinea, Sierra Leone, Liberia, Côte d'Ivoire, Ghana, Nigeria, Cameroon, Central African Republic and DR Congo. The flexible stems are used as ties in Ghana, especially to fasten rafters, and the fruit is used as a laxative.

Loeseneriella urceolus (Tul.) N.Hallé (synonym: *Hippocratea urceolus* Tul.) is a liana of forests and bushland restricted to Madagascar and the Comoros. A decoction of its leaves is used as a mouthwash.

Growth and development *Loeseneriella africana* has a low growth rate and unlike more aggressive species of lianas, it seems to have no significant effect on the regeneration of forest trees. In West Africa flowering usually takes place in the second half of the dry season. The winged seeds are dispersed by wind.

Ecology *Loeseneriella africana* occurs from sea-level up to 2450 m altitude in a wide range of rainfall zones and in many different vegetation types, from rainforest to woodland and open rocky places. In the Sahelian and Sudanian zones it occurs in shade and is often riparian.

Propagation and planting No attempts have been made to cultivate *Loeseneriella africana* but multiplication with seeds is easy. Natural regeneration takes place in the shade.

Genetic resources As the species is widespread there seems to be no risk of extinction. However, all species of the genus risk localized loss of genetic variation and extinction as a result of unsustainable harvesting and overexploitation.

Prospects In the future *Loeseneriella africana* will continue to be used locally but alternatives need to be explored and sustainable management options to be developed.

Major references Burkill, 1985; Hallé, 1990; Lebrun & Stork, 2010; Robson et al., 1994; Wilczek, 1960b.

Other references Arbonnier, 2000; Beentje, 1994b; Berhaut, 1974; Debray, Jacquemin & Razafindrambao, 1971; Gelfand et al., 1985; Hallé, 1962; Hallé, 1978; Jansen et al., 2008; Latham, 2004; Medley & Kalibo, 2007; Okokon, Antia & Umoh, 2008; Okokon, Ita & Udokpoh, 2006; Robson, 1966; Taïta, 2003; Toledo-Aceves & Swaine, 2008b; Tra Bi, Kouamé & Traoré, 2005; Tra Bi et al., 1999.

Sources of illustration Akoègninou, van der Burg & van der Maesen, 2006.

Authors R.B. Jiofack Tafokou & C.H. Bosch

LOESENERIELLA APOCYNOIDES (Welw. ex Oliv.) N.Hallé ex J.Raynal

Protologue Fl. Médec. tradit. Rwanda: 119 (1979).

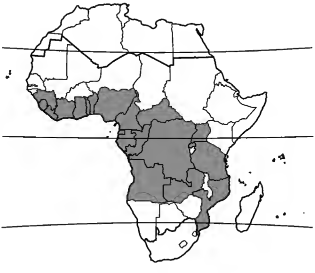
Family Celastraceae (Hippocrateaceae)

Synonyms *Hippocratea apocynoides* Welw. ex Oliv. (1868), *Hippocratea guineensis* Hutch. & M.B.Moss (1928).

Origin and geographic distribution *Loeseneriella apocynoides* is distributed from Guinea eastward to Uganda and Tanzania and southward to Angola, Zambia and Mozambique.

Uses The woody stems are widely used for tying. In Nigeria, for instance, they are a preferred tying material in house construction because of their resistance to termites. Around the Bwindi Impenetrable National Park in Uganda the stems are in high demand especially for making woven stretchers to transport patients to hospitals, for making carrying and tea-picking baskets and woven pot covers, and for the construction of granaries.

Properties The stems are long, flexible, very strong, lightweight and durable, being resistant to fungi and wood-boring insects. In



Loeseneriella apocynoides – wild

Uganda stretchers made from *Loeseneriella apocynoides* last 3–5 years.

Botany Liana usually 10–30 m long, sometimes longer; stem grooved; young branches rusty hairy. Leaves opposite, simple; stipules reduced, hairy; petiole 3–9 mm long, hairy; blade elliptical to oblong or ovate, (2.5–)4–15(–17) cm × 1.5–7(–8.5) cm, rounded to cordate or cuneate at base, obtuse or acuminate at apex, margin entire or rarely toothed, greyish green above, brownish beneath, hairy beneath when young, especially on the veins, with 5–10 pairs of secondary veins. Inflorescence an axillary, simple or compound, dichasial cyme 1.5–9 cm long, sometimes a terminal panicle, axes and bracts rusty hairy, several–many-flowered. Flowers bisexual, regular, 3–8 mm in diameter, greenish, greyish or yellowish, sometimes slightly reddish; pedicel 0.5–3 mm long, rusty hairy; sepals 5, subequal, deltoid, 0.5–1.5 mm long, hairy; petals 5, valvate, deltoid, ovate or narrowly triangular, 1.5–5.5 mm × 0.5–2 mm, hairy; stamens 3; ovary 3-celled, style c. 0.5 mm long. Fruit of 3 dehiscent, flat, elliptical mericarps, each mericarp 4–7 cm × 2–4 cm and 4–6-seeded, reddish brown, glabrous. Seeds 3–4.5 cm × 1–1.5 cm, with a wing with marginal and median vein. Seedling with hypogeal germination.

The Old World genus *Loeseneriella* comprises about 16 species. Within *Loeseneriella apocynoides* 2 varieties are recognized.

Growth of *Loeseneriella apocynoides* is slow. In Uganda it takes an estimated 10–20 years before stems with a diameter of 3–4 cm have formed. After chopping, the remaining part sprouts readily. In Ghana, Benin and Nigeria flowering is in July–November.

Ecology *Loeseneriella apocynoides* occurs at 300–2135 m altitude in damp forest, swamp or temporarily inundated forest, riverine forest, secondary thickets, open gaps in secondary deciduous forest, abandoned fields, and occasionally in forests on slopes or rocky outcrops.

Management Stems are collected exclusively from the wild. Stems 2–4 cm in diameter are cut at about 30 cm above the ground. After being cut into pieces of a suitable length, they are wound and split into strips that can be used for weaving. Sometimes the stems are stored whole, and when weaving material is needed they are soaked in water for about 7 days, after which they are split. Dried stems can be stored for up to 10 years.

Genetic resources and breeding The factors length, strength and durability make *Loeseneriella apocynoides* the most popular species for weaving around the Bwindi Impenetrable National Park in Uganda. As a result the species is seriously overexploited, and even in a protected area like the Bwindi Impenetrable National Park plants stems with a usable diameter have become scarce.

Prospects *Loeseneriella apocynoides* is locally overexploited. To make exploitation of this species more sustainable, it may be worthwhile to investigate the possibilities for its cultivation.

Major references Burkill, 1985; Hallé, 1990; Muhwezi, Cunningham & Bukenya-Ziraba, 2009; Ndangalasi, Bitariho & Dovie, 2007; Robson et al., 1994.

Other references Abbiw, 1990; Akoègninou, van der Burg & van der Maesen, 2006; Bitariho et al., 2002; Cunningham, 1996; da Silva, Izidine & Amude, 2004; Hallé, 1962; Irvine, 1961; Keay & Blakelock, 1958; Robson, 1966; Wilczek, 1960b.

Authors M. Brink & C.H. Bosch

LOUDETIA SIMPLEX (Nees) C.E.Hubb.

Protologue Bull. Misc. Inform. Kew 1934: 431 (1934).

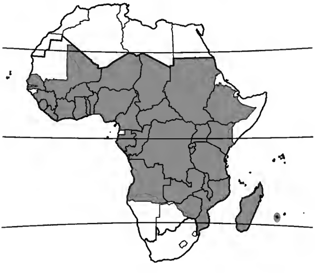
Family Poaceae (Gramineae)

Chromosome number $2n = 24, 40, 60$

Synonyms *Tristachya simplex* Nees (1841), *Arundinella stipoides* Hack. (1884), *Loudetia camerunensis* (Stapf) C.E.Hubb. (1934), *Loudetia stipoides* (Hack.) Conert (1957).

Vernacular names Common russet grass (En).

Origin and geographic distribution *Loude-*



Loudetia simplex – wild

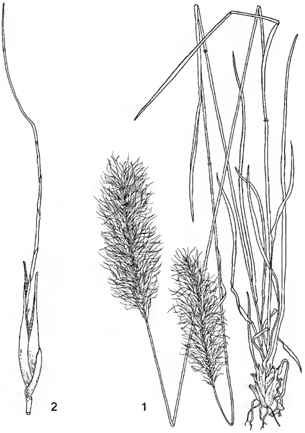
tia simplex is widely distributed throughout tropical Africa, including Madagascar. It also occurs in South Africa.

Uses *Loudetia simplex* is commonly used for thatching. In Zambia it is reputed to be among the best thatching grasses available. In the Bamako market in Mali, baskets made of the stems are traded. In Madagascar *Loudetia simplex* is used for making baskets and hats. Young growth provides grazing. It is said to become unpalatable when mature and dry. In Burkina Faso the dislike is ascribed to a bitterness of the leaves. In many areas it has become a dominant grass indicative of poor soil or overgrazing. In Zimbabwe a maceration of the whole plant in water is used as a wash for treating athlete's foot.

Production and international trade *Loudetia simplex* is only used and traded locally.

Properties Analysis of the fodder value of fresh plants in the early bloom stage in Kenya indicated (on a dry matter basis): 10.4% crude protein, 38.0% crude fibre, 5.6% ash, 1.8% ether extract and 44.2% N-free extract.

Botany Perennial, tufted grass; stems 30–150 cm tall, usually erect, unbranched, nodes yellowish to black, glabrous to bearded. Leaves alternate; basal sheaths usually becoming fibrous, typically woolly tomentose but sometimes silky pubescent to glabrescent; ligule a ciliate fringe; blade linear, flat or rolled-in, rarely filiform, 10–30 cm × 2–5 mm. Inflorescence a linear to narrowly ovate panicle 5–30 cm long, contracted or loose, the branches seldom markedly whorled. Spikelets with 1 basal male floret and 1 upper bisexual floret, narrowly lanceolate, 8–14 mm long, pale to dark brown, mostly glabrous but sometimes bristly haired from dark tubercles, disarticulating below the upper floret and tardily so below the lower floret; glumes 3-veined; lower glume ovate-elliptical, usually one-third as long as the spikelet and broadly obtuse but sometimes half as long and narrowly obtuse; upper glume lanceolate, as long as the spikelet, obtuse; lower lemma similar to the upper glume, 3-veined; upper lemma oblong-elliptical, 4–7 mm long, thinly coriaceous, glabrescent to pilose, 7-veined, acutely bidentate with lobes up to 1 mm long; awn 2.5–5 cm long; callus narrowly oblong, 0.8–1 mm long, 2-toothed; palea-keels with thickened veins, wingless; stamens 2, 3 mm long; ovary with style c. 2 mm long and stigmas c. 2 mm long. Fruit a lanceolate caryopsis c. 5 mm long, glabrous, hilum linear.



Loudetia simplex – 1, habit; 2, spikelet.
Source: Flore analytique du Bénin

In Benin *Loudetia simplex* flowers in June–January, in Zimbabwe in November–March. It sets seed and turns reddish-yellow when the annual cycle is completed, even if the soil has not dried out. After the rains, the whole tussock dries off and usually burns. After the fires there is a rather sparse regrowth of green leaves and some dry-season flowering. The main regrowth from the perennial tussock occurs after the onset of the next rains. *Loudetia simplex* uses the C_4 photosynthetic pathway.

Loudetia is classified in the *Arundinelleae* and comprises about 20 or 26 species depending on the generic circumscription accepted. It is distributed in tropical and South Africa and in Madagascar, with 1 species in South America. *Loudetia arundinacea* (A.Rich.) Steud. is a perennial, robust, tufted grass with stems up to 3 m tall, occurring widespread from Senegal eastward to Cameroon and Ethiopia, and southward to Angola and Mozambique. It is a dominant grass in some savanna types and often forms pure stands. It is widely used for thatching, for instance in Sierra Leone and Nigeria, but its thatch is reported not to be durable. In Uganda the flowering stems are bundled to make brushes and brooms. The grass provides browse for cattle, especially while still young. In Kordofan (Sudan) it is said to recover rapidly after fire, and cattle will graze the new growth until it reaches about 40 cm in height. When older, the hairs on the mature inflorescence become troublesome to the eyes of cattle. *Loudetia togoensis* (Pilg.) C.E.Hubb. is an annual, tufted grass with stems up to 1 m tall. It is common across the Sahel from Mauritania to Sudan. The flowering stems are bundled into brooms in Ghana and Nigeria. In Burkina Faso the stems are plaited into hats, and in Togo into bracelets. The grass provides browse for stock, but only while still young.

Ecology *Loudetia simplex* occurs at 250–2500(–2750) m altitude in deciduous bushland and savanna grassland in areas with an average annual rainfall of (600–)750–1000 mm. It is not very tolerant of drought. *Loudetia simplex* grows on generally poor, coarse, sandy soils, but may also be found on stony slopes or on the edges of wetlands. In Ghana it is common on rocky hillsides and shallow soils overlying impermeable ironstone hardpan or bedrock. In Tanzania it is reported on infertile lateritic soils low in organic matter, derived from granite. The soil texture varies from sand to clay with a pH range of 5–7.5. In Côte d'Ivoire it is characteristic of *Borassus aethiopum* Mart. palm savanna. Burning of the savanna does not affect it or its proportion of the plant cover.

Management *Loudetia simplex* only occurs wild.

Genetic resources and breeding *Loudetia simplex* is extremely widespread and common, and in no danger of genetic erosion.

Prospects *Loudetia simplex* is likely to remain a thatching and plaiting grass of local importance and a fodder grass of moderate importance in natural grassland.

Major references Burkill, 1994; CIAT/FAO, undated-a; Clayton, Phillips & Renvoize, 1974; Dougall & Bogdan, 1958; Poilecot, 1995.

Other references Chifundera, 2001; Clayton, 1971; Conert, 1957; Jacques-Félix, 1972; Lubke & Phipps, 1973; McVaugh, 1974; Medina, 1959; Phillips, 1995; Rommerskirchen et al., 2006; Shava & Mapaura, 2002.

Sources of illustration Akoègninou, van der Burg & van der Maesen, 2006.

Authors L.P.A. Oyen

LUFFA CYLINDRICA (L.) M.Roem.

Protologue Fam. nat. syn. monogr. 2: 63 (1846).

Family Cucurbitaceae

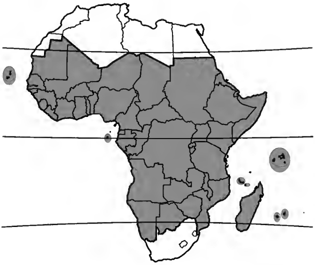
Chromosome number $2n = 26$

Synonyms *Momordica cylindrica* L. (1753), *Luffa aegyptiaca* Mill. (1768).

Vernacular names Smooth loofah, sponge gourd, vegetable sponge, dishcloth gourd, dishrag gourd, rag gourd (En). Courge torchon, éponge végétale, liane torchon, pétole, luffa (Fr). Esponja vegetal (Po). Uziuzi, madodoki, mdodoki (Sw).

Origin and geographic distribution *Luffa cylindrica* is widely distributed in the tropics and subtropics, as a cultivated and naturalized plant. Its cultivation is of ancient origin and it is hard to determine whether the native home is Africa or Asia. The plant occurs wild in West Africa, but this is often believed to be a result of escape from cultivation, as the plant is known as 'white people's sponge' in several communities in the region. However, evidence of an Asian origin is rare. How the plant has spread over the entire tropical zone is also not clear. Some argue for ocean currents as a dispersal mechanism, but more often human dispersal is raised as the probable cause of the wide distribution of *Luffa cylindrica*.

Uses When the fruit becomes old and dry the endocarp becomes a persistent fibrous vascular network which is used in various ways. A major use is as a sponge for washing and scrubbing utensils as well as the human body. It is also used for the manufacture of hats, insoles of shoes, car-wipers, pot-holders, table-mats, door and bath-mats, sandals and gloves. The



Luffa cylindrica – planted and naturalized fibre has also been used for its shock and sound absorbing properties, for instance in helmets and armoured vehicles, and as a filter in engines. In Ghana the dry fibre is used to filter water and palm wine. In Central Africa it is used to brush clothes. Fungal biosorbents immobilized on *Luffa cylindrica* sponges have been used for the biosorption of heavy metals from olive oil mill wastewater and other wastewaters.

The young fruit is eaten fresh or cooked as a vegetable, but it has to be picked before the fibrous vascular bundles harden and before the purging compounds develop. In Guinea and Côte d'Ivoire edible cultivars are grown. Edible forms have also been developed in India and the Philippines where the plant is commonly cultivated. In India and China a type of curry is prepared with the fruit which is peeled, sliced and fried. In Japan the fruits are eaten fresh or sliced and dried to be eaten later. The leaves are also eaten as a vegetable. The roasted seeds are edible and contain an edible oil. The oil has been used in the United States in soap manufacture. The bitter and toxic seedcake is unsuitable as feed for cattle, but can be used as fertilizer given that it is rich in N and P. The fruits and leaves are browsed by goats. Bees feed on the flowers.

In traditional African medicine pulp of the whole plant is used as a suppository against constipation. Root preparations are taken for the treatment of constipation and as a diuretic. In Gabon a root preparation is used as remedy of nose cancer. In DR Congo a decoction of the roots and leaves is recorded to be drunk or used in an enema as an abortifacient, but in Tanzania a root decoction and leaf sap are recorded to be drunk to reduce the danger of abortion. The leaves are used to promote wound healing and to maturate abscesses. In Togo leaf preparations are applied on oedemas and taken for the treatment of malaria. In the Central African Republic ground leaves are introduced rectally for the treatment of enterobiasis. In Congo the leaf juice is considered to be effective against filaria, and an aqueous maceration of fresh leaves is taken for the treatment of whooping cough. In Rwanda the leaves are pounded with water and the sap is taken for the treatment of stomach-ache. In Uganda leaf preparations are used to facilitate childbirth. Zulu people in South Africa take a leaf decoction to treat stomach-ache. The fruit is used in Guinea on tumours and swellings, and the fruit pulp is used in Guinea and Nigeria as an emollient. The fruit sap is taken as a strong purgative. The seeds are credited with emollient and anthelminthic properties. They are also emetic and cathartic. The seed oil is used for the treatment of skin problems. Unripe fruits have been used as fish poison.

Production and international trade Japan is among the primary world producers and importers of *Luffa cylindrica* sponges and has established a grading system to ensure uniformity. Products from Japan are considered to be of superior quality. In recent years the product has been imported from Japan into the United States as cosmetic sponge. There is also trade between the United States and other countries in Asia and Latin America. It is a traditional product of commerce in the whole Mediterranean, known under the arabic name 'luff'. *Luffa cylindrica* sponges are produced and traded in tropical Africa, but statistics are not available. Commercial grade sponges are preferably between 15 and 40 cm long, free of seeds and with pale, uniform colour. Young fruits can be found as a vegetable in Chinese groceries in the West.

Properties Sponges from the fruit of *Luffa cylindrica* are soft and non-scratching, making them very suitable as wash cloth and for cleaning glass and china. The sponges tolerate mechanical stress and resume their original shape after being pressed down. Moreover, they are rotproof and appreciated in body care as a substitute for massage gloves. *Luffa cylindrica* fibre has a high water absorption capacity, making it suitable as an absorbent, for instance to decolour aqueous effluents. Another potential use is the reinforcement of resin matrix composite materials, but in this case a barrier layer, for instance of glass fibres, is necessary to avoid water absorption from the environment. The sponge has a high degree of porosity, high specific pore volume, stable physical properties and is non-toxic and biodegradable. These properties make it suitable as support matrix to plant, algal, bacterial and yeast cells. The fibre strands contain 50–62% α-cellulose, 20–28% hemicellulose and 10–12% lignin.

The raw leaves contain per 100 g edible portion: moisture 94.0 g, energy 58 kJ (14 kcal), protein 1.6 g, fat 0.1 g, carbohydrates (including fibre) 2.7 g, ash 1.6 g, Ca 330 mg, P 33 mg (Leung, Busson & Jardin, 1968). Leaf extracts, containing saponins, alkaloids and cardiac glycosides, have shown antibacterial activity against *Bacillus subtilis*, *Escherichia coli*, *Staphylococcus aureus* and *Salmonella typhi*. Aqueous extracts of the leaves have shown in-vitro oxytocic activity. In one study ethanolic leaf extracts showed in-vitro antiplasmodial activity against *Plasmodium falciparum*, while in another study the crude ethanolic extract had no significant antimalarial activity, but the petroleum ether fraction of the ethanolic extract was active against *Plasmodium falciparum*.

The immature fruit contains per 100 g edible portion: moisture 94.0 g, energy 88 kJ (21 kcal), protein 0.6 g, fat 0.2 g, carbohydrates 4.9 g, Ca 16 mg, P 24 mg, Fe 0.6 mg, vitamin A 235 IU, thiamin 0.04 mg, riboflavin 0.02 mg, niacin 0.3 mg and ascorbic acid 7 mg. The fruit also contains saponins. Fruits of wild forms are bitter and poisonous. Various antioxidant compounds have been isolated from the fruit. Lucyosides isolated from the fruit have shown antitussive activity. Ethanolic extracts of the fruit have shown antibacterial and antifungal activity.

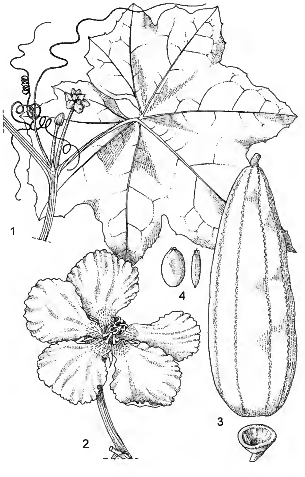
Seeds from Sudan contained per 100 g: moisture 4.1 g, protein 32.8 g, fat 37.0 g, crude fibre 12.7 g, carbohydrate 8.9 g and ash 4.5 g. Dehulled seeds from Nigeria contained per 100 g: moisture 2.3 g, crude protein 37.6 g, crude fat 42.3 g, crude fibre 3.0 g, carbohydrate 10.6 g and ash 4.3 g. Seed extracts, containing saponins, alkaloids and cardiac glycosides, have shown antibacterial activity against *Bacillus subtilis, Escherichia coli, Staphylococcus aureus* and *Salmonella typhi*. Luffin-a and luffin-b, proteins isolated from the seed, have shown abortifacient and antitumour activity, and protein-biosynthesis inhibitory activity. Luffacylin, luffin p1 and luffin-s have shown ribosome inactivating activity; luffacylin also has antifungal activity against *Fusarium oxysporum* and *Mycosphaerella arachidicola*, and luffin p1 has anti-HIV-1 activity. The seed contains various triterpene saponins, some of them highly toxic. Two triterpenoids isolated from the seed (sapogenins 1 and 2) have shown in-vivo immunostimulatory effects in mice. The triterpene oleanolic acid has shown anti-inflammatory activity. Aqueous seed extracts and polysaccharides and proteins from the seed have shown in-vitro antitumour activity. An ethanolic extract of the seed reduced blood glucose levels in streptozotocin diabetic rats, but had no effects on blood glucose levels in normal rats.

The seed oil is variously described as colourless or green or brownish, probably depending on the extraction method. The main fatty acids in the seed oil are palmitic acid (10–23%), stearic acid (7–19%), oleic acid (7–40%) and linoleic acid (43–65%).

Bryonolic acid, a pentacyclic triterpene isolated from cultured cells of *Luffa cylindrica*, has shown in-vivo anti-allergic and anti-inflammatory effects in rats and mice.

Adulterations and substitutes The fruit of *Luffa acutangula* (L.) Roxb. ('ridged gourd') is primarily used as a vegetable but when dry its fibre can also be used as a sponge. However, the sponge of *Luffa acutangula* is of low quality and therefore the plant is rarely grown for its spongy characteristics.

Description Monoecious, annual, climbing or trailing herb up to 15 m long, stem 5-angled, finely hairy; tendrils 2–6-fid. Leaves alternate, simple; stipules absent; petiole up to 15 cm long; blade ovate in outline, 6–25 cm × 6–27 cm, palmately 3–7-lobed with triangular or ovate lobes, cordate at the base, lobes acute or



Luffa cylindrica – 1, part of stem with leaf and flower buds; 2, male flower; 3, dehisced fruit; 4, seeds.

Redrawn and adapted by Achmad Satiri Nurhaman

subacute and apiculate at the apex, margin sinuate-dentate, scabrous, dark green, palmately veined. Male inflorescence racemose, 5–20-flowered; peduncle 7–32 cm long, finely hairy; female flowers solitary. Flowers unisexual, regular, 5-merous, 5–10 cm in diameter; petals free, entire, broadly obovate, 2–4.5 cm long, deep yellow; male flowers on bracteate pedicels 3–13 mm long, receptacle tube obconic below, expanded above, 3–8 mm long, with triangular lobes 8–12 mm long, sepals ovate, 8–14 mm long, stamens 3 or 5, free, inserted on the receptacle tube, connectives broad; female flowers on pedicel 1.5–14.5 cm long, receptacle tube shortly cylindrical and 2.5–6 mm long, with ovate lobes c. 1 cm long, sepals ovate-lanceolate or lanceolate, 8–16 mm long, ovary inferior, stigmas 3, 2-lobed. Fruit an ellipsoid or cylindrical capsule up to 60(–90) cm × 10(–12) cm, beaked, not prominently ribbed, brownish, dehiscent by an apical operculum, glabrous, many-seeded. Seeds lenticular, broadly elliptical in outline, compressed, 10–15 mm × 6–11 mm × 2–3 mm, smooth, dull black, with a narrow, membranous wing-like border. Seedling with epigeal germination; cotyledons ovate, c. 5 cm long.

Other botanical information *Luffa* comprises 7 species, 4 of these native to the Old World tropics and 3 somewhat more distantly related species indigenous to South America. *Luffa cylindrica* hybridises with other species of the genus, but in most cases hybrids show a great reduction in fertility or even sterility. Hybrids of *Luffa cylindrica* and *Luffa acutangula* are found in cultivation. These are bitter and inedible, but suitable for the production of sponges.

Within *Luffa cylindrica* cultivated and wild forms are distinguished:

- Smooth Loofah Group (synonym: var. *aegyptiaca*): the large-fruited, less bitter, cultivated forms, with different cultivars for the production of the best sponge or the best vegetable.
- var. *leiocarpa* (Naudin) Heiser & Schilling: the wild forms occurring in Asia.

Anatomy The differentiation of the strands in the fruit begins when the ovary primordium is about 1 mm and new strands continue to form until cell division ceases. A complex anastomosing fibre network is then produced. Each fibre consists of 200–500 cells connected by their cell wall and surrounding a central longitudinal channel. The fibre elements are in fact dead sclerenchymatic cells with thick, lignified walls and reabsorbed protoplasm. The fibres are difficult to separate and can differ considerably in diameter, length, and spacing of the fibre strands.

Growth and development Flowers open in the early morning. Pollination is by insects. *Luffa cylindrica* is self-compatible and natural propagation is by seed. At maturity, the operculum of the fruit opens and frees the seeds which are carried by wind, though not over long distances.

Ecology *Luffa cylindrica* persists in old cultivations and near dwellings, frequently becoming naturalized in forest, woodland, bushland, thicket and grassland, from sea-level up to 1500(–1800) m altitude.

In cultivation the crop grows well in tropical regions. In temperate regions it is suitable for summer growing conditions. The plant is sensitive to frost. Excessive rainfall during flowering and fruiting adversely affects fruit yields. A deep sandy loam is preferred.

Propagation and planting Propagation is by seed. The 1000-seed weight is 70–100 g. In cultivation the seeds are saved from the previous crop. Seeds of hybrid cultivars should not be collected for planting. Germination is best at temperatures of 20–30°C. Plantations can be established by direct sowing or transplanting. *Luffa cylindrica* is usually planted c. 1 m apart.

Management Like many other cucurbit species *Luffa cylindrica* has a moderate nutrient requirement. In cultivation a trellis is required to support the climbing stem. In Africa the plant is mostly grown in home gardens with little management. For commercial production of *Luffa cylindrica* sponges it is important to adequately manage plant spacing, fruit size and the number of fruits per plant as this might influence yields. Side branches are best pruned to promote growth of the main stem, and not more than 20–25 fruits per stem should be allowed to grow.

Diseases and pests A number of common cucurbit diseases and pests are also found in *Luffa cylindrica* cultivation. These include powdery mildew, downy mildew, pumpkin flies and red spider mite. For instance several species of pumpkin flies (including *Bactrocera depressa* and *Bactrocera scutellata*) attack the immature fruit. These dark brown insects penetrate the fruit skin and the tissue around the puncture mark dries and becomes darker and slightly sunken.

Harvesting Mature fruits to be used for their fibre are harvested 3–6 months after sowing, when they start to turn yellow. Fruits for consumption should be harvested before they become fibrous; their harvesting starts 2 months after planting. Immature fruits do not store well, and should be marketed or prepared for consumption as soon as they are harvested.

Yield Reports from India and Japan show that *Luffa cylindrica* can produce more than 62,000 fruits/ha with a plant density of 11,000 plants/ha, the number of fruits per plant being limited to 5–6. In natural stands, the number of fruits produced per plant can be much higher than 6. For instance, a report from Columbia indicated that with 5300 plants/ha the production was 200,000 fruits/ha with a fruit size of 30–90 cm × 8–12 cm and a crop cycle of 15 months.

Handling after harvest The basic method for preparing sponges is to immerse the dry, mature fruit in water for 2–3 days to soften the skin and flesh and be able to easily remove these and the seeds. In other processing methods boiling water is used. In commercial enterprises the fruits are placed in tanks with running water until the skin and pulp disintegrate, after which they are washed to remove the pulp and seeds. The fibrous endocarp is bleached in a sodium hypochlorite solution before a final washing and drying, or it is dried and bleached in the sun.

Genetic resources The largest ex-situ collections of *Luffa* species are held in the United States, India and the Philippines. A DNA bank of 131 accessions of *Luffa cylindrica* collected from 8 West African countries is available at the Genebank Department of the Leibniz Institute of Genetics and Crop Plants Research (IPK, Gatersleben). Genetic resources of wild forms are not under threat as the species is ubiquitous and grows widely in tropical regions. Cultivated forms in Africa, however, require urgent inventory and conservation actions to promote local growers' efforts for cultivar selection and improvement.

Breeding Variability exists in the thickness of the outer zones of the fibre network (which form the bulk of the sponge), the compactness of the network, the diameter of the strands and the length of the fibre cells. These traits are inherited and thus offer prospects for selection and breeding. Numerous cultivars and interspecific hybrids are available in the major production countries.

Prospects *Luffa cylindrica* fruits are a very useful local source of fibre used for sponges and other applications and of edible fruits. There may even be scope for commercial production of sponges for the export market. To increase the profitability, the production of sponges combined with oil extraction from the seeds may offer prospects. The wide application in traditional medicine and the results of pharmacological investigations indicate medicinal potential.

Major references Bal, Bal & Lallam, 2004; Burkill, 1985; Heiser & Schilling, 1990; Jansen, Gildemacher & Phuphathanaphong, 1993; Jeffrey, 1995; Kabele Ngiefu, Paquot & Vieux, 1976; Neuwinger, 2000; Oboh & Aluyor, 2009; Onelli, Patrignani & Carraro, 2001; Purseglove, 1968.

Other references Anandjiwala et al., 2007; Berhaut, 1975a; Boynard & D'Almeida, 1999; Dairo, Aye & Oluwasola, 2007; Du et al., 2006; El-Fiky, Abou-Karam & Afify, 1996; Esquinas-Alcazar & Gulick, 1983; Gbeassor et al., 1990; Gessler et al., 1994; Grindley, 1950; Ibrahim et al., 1999; Kamatenesi-Mugisha et al., 2007; Khajuria et al., 2007; Leung, Busson & Jardin, 1968; Liu et al., 1998; Neuwinger, 1996; Ng, Chan & Yeung, 1992; Oyetayo, Oyetayo & Ajewole, 2007; Porterfield, 1955; Sinnot & Bloch, 1943.

Sources of illustration Jeffrey, 1967.

Authors E.G. Achigan-Dako, S. N'danikou & R.S. Vodouhê

MANNIOPHYTON FULVUM Muell.Arg.

Protologue J. Bot. 2: 332 (1864).

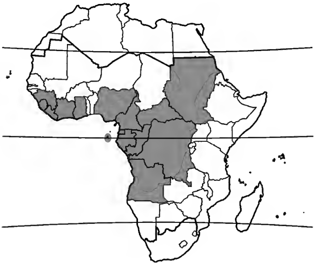
Family Euphorbiaceae

Synonyms *Manniophyton africanum* Müll.Arg. (1864), *Manniophyton wildemanii* Beille (1910), *Manniophyton tricuspe* Pierre ex A.Chev. (1940).

Origin and geographic distribution *Manniophyton fulvum* is distributed only in tropical Africa, from Sierra Leone eastward to Sudan and southward to Angola.

Uses The stems of *Manniophyton fulvum* are used in Central Africa to make traps. The split stems are used in basketry. The inner bark is rolled into narrow lines and knotted into nets for hunting. It is also used to make rope and thread; in Central Africa many farm tools and other objects are bound with rope made from the inner bark. The bark yields a strong fibre, resistant to rot, which is widely used to make lines, ropes and nets by fishers and hunters.

In Nigeria the cooked seeds are eaten as food and the leaves are browsed by sheep and goats.



Manniophyton fulvum – wild

In African traditional medicine the root, stem, bark and leaf are credited with analgesic properties, and they are used against diarrhoea, stomach-ache, cough and bronchitis. The red stem-sap is credited with haemostatic properties and is used to heal wounds. It is also used against dysentery, haemorrhoids, haemoptysis and dysmenorrhoea. In Côte d'Ivoire the stem sap is used against skin infections and painful menstruation. Stem decoctions are drunk to heal gonorrhoea. The leaf sap or the powder of dry leaves is sprinkled on sores. The leaf sap is also used against heart problems, ear problems, caries and insanity. Leaf decoctions are used in case of inflammations, and the crushed leaf is applied for the treatment of inflammation of the throat. Seeds are used against haemorrhoids and blood disorders.

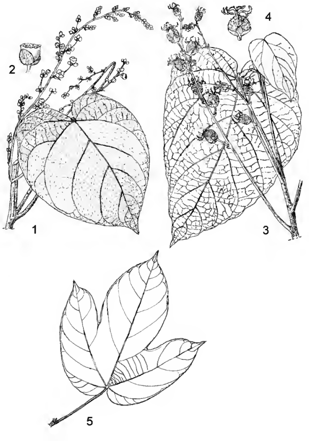
The powdered dried root bark is a poison for which *Piliostigma thonningii* (Schumach.) Milne-Redh. is used as antidote.

Production and international trade *Manniophyton fulvum* is collected from the wild. In Nigeria the seed is a commercial product, procuring substantial income to local communities, but no production data are available.

Properties The bark fibre is strong and durable, making it sought after by fishermen and hunters for the production of nets.

Contact of the plant with the skin causes itching and may result in sores. The stem produces a red sap which becomes tacky in contact with air. A methanolic extract from the leaves contained flavonoids, tannins, phlobatannins, saponins and traces of alkaloids. The ethyl acetate fraction of a methanolic extract of the leaves showed anti-oxidant activity. Anti-inflammatory properties were demonstrated as well. The seed contains about 50% oil. This oil thickens on exposure in thin films and could be used for paint production. However, its iodine value is low (around 100). Leaves collected in Nigeria contained 14.4 g crude protein per 100 g dry matter.

Description Dioecious shrub or climber up to 30(–40) m long; stem cylindrical, up to 12 cm in diameter, with red sap; branches scabrous with short stellate hairs. Leaves alternate, simple; stipules caducous; petiole up to 19(–28) cm long; scabrous, pubescent; blade unlobed and ovate or 2–5-lobed, often asymmetrical, up to 35 cm × 28(–35) cm, base cordate, apex sharply acuminate, margin entire, scabrous-setose with stellate hairs on both surfaces. Inflorescence an axillary panicle; male panicle slender, up to 45 cm long, female panicle much smaller. Flowers unisexual; male flowers clustered, gamopetalous, pedicel 3–5 mm long, calyx lobes triangular, hairy, corolla tube 4–6 mm long, white to yellowish green, stamens 10–20, filaments free; female flowers with pedicel 4–6(–13) mm long, sepals 5, 2–2.5(–6) mm



Manniophyton fulvum – 1, twig with male flowers; 2, male flower; 3, twig with female flowers; 4, female flower; 5, leaf.
Redrawn and adapted by Iskak Syamsudin

× 2–2.5(–6) mm, petals 5, free, 5–6 mm × 4–5 mm, yellowish green, ovary densely hairy, style 4–5 mm long. Fruit a capsule 1.8–2.5 cm × 2.8–3.3 cm, with raised ribs, deeply 3-lobed, brown, rusty-tomentose. Seeds 1.3–1.5 cm long, brown, shiny.

Other botanical information *Manniophyton* is a monotypic genus.

Growth and development *Manniophyton fulvum* grows fast, which enhances site colonization and mitigates competition of other species. It is a straggling heliophilous plant which flowers in May–August in Ghana and in November–December in Cameroon.

Ecology The species occurs in primary and secondary forest. It can become invasive in forest openings and in riparian forest. It is also found in roadsides, abandoned areas, fallow areas and plantations.

Propagation and planting *Manniophyton fulvum* is dispersed by insects and birds which consume the fruits. The plant can be propagated by seed.

Harvesting Harvest of products is year-round.

Yield In DR Congo it has been estimated that 20 kg of green stems yield 2 kg of bark from which 350 g of fibre is extracted.

Handling after harvest Extraction of the fibre from the stem is slow and difficult. To obtain the fibre, the stem is cut into segments 1–2 m long, which are scratched to remove the stellate hairs. Hand removal of the hairs can cause itching. The green stems remaining after the removal of the hairs are carefully incised with a knife, and the bark is removed in one piece. The strips obtained are separated from the cambium and other non-fibrous parts and sun-dried for several days. After the strips have been further softened by leaving them overnight outside, they are split into fibres by pounding them with a wooden mallet.

Genetic resources *Manniophyton fulvum* is planted in Aburi botanical gardens in Ghana where nine accessions are available. The species is common in the Guineo-Congolian forests and not under any threat of extinction or genetic erosion. However, investigations on the genetic structure of populations are due.

Prospects For many communities in tropical Africa *Manniophyton fulvum* is a useful raw material used in the manufacture of a range of products, including baskets, cordage and nets. Little is known about the properties, however, and there is room for research to describe the anatomical structure and physical properties of the fibres. The drying oil has a low iodine value and may contain complex fatty acids as are commonly found in *Euphorbiaceae*. The antioxidant properties of the leaves may offer an opportunity to obtain natural antioxidant compounds useful in food conservation. Research in this field should be accompanied with toxicological analyses to establish whether such products are suitable for human consumption. Exploitation of the anti-inflammatory properties of the leaves requires as well investigations and determination of active compounds of biological and medicinal interest. There may be prospects for the domestication of the plant, for instance to serve the niche market for the seeds in Nigeria.

Major references Burkill, 1994; Dubois, 1951; Kalanda, Ataholo & Ilumbe, 1995; Léonard, 1962; MacFoy & Sama, 1983; Motte, 1980; Muanza, Dangala & Mpay, 1993; Nia et al., 2005; Tanno, 1981; Terashima & Ichikawa, 2003.

Other references Akobundu & Agyakwa, 1998; Bahuchet, 1993; Bognon, 1991; Brown, Hutchinson & Prain, 1909–1913; Caballé, 1998; Hewlett, 1996; Irvine, 1961; Keay, 1958b; Letouzey, 1982a; Neuwinger, 2000; Ngodigha & Oji, 2009; Okoli et al., 2003; Raponda-Walker & Sillans, 1961; Takeda, 1996; Téré, 2000; Tra Bi, Kouamé & Traoré, 2005; White & Abernethy, 1997.

Sources of illustration Hawthorne & Jongkind, 2006; Hooker, 1878.

Authors R.B. Jiofack Tafokou

MAPANIA LINDERI Hutch. ex Nelmes

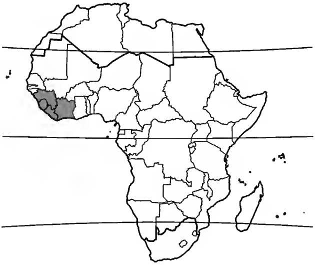
Protologue Kew Bull.: 421 (1952).

Family Cyperaceae

Origin and geographic distribution *Mapania linderi* is distributed from Guinea to Côte d'Ivoire.

Uses The leaves are used for thatching in Liberia.

Botany Perennial, robust herb with a woody, vertically growing rhizome 5–20 mm in diameter; stems solitary, up to 30 cm tall, 1–3 mm in diameter, terete, glabrous, green to reddish brown. Leaves inserted in the lower part of the stem; sheath linear to linear-lanceolate, 4.5–9 cm × 1–2.5 mm, apex narrowed into pseudo-petiole 4–30 cm × 1–2.5 cm, dark green to reddish; blade broadly linear, 30–130 cm × 1.5–5 cm, base transformed into a pseudo-petiole, asymmetrical and acute to acuminate at the



Mapania linderi – wild

apex, margin finely serrate, papery or leathery, dark green, 3-veined, veins brown to black. Inflorescence a terminal, dense, nearly globose head 1.5–2.5 cm in diameter with numerous composite spikes; involucral bracts 4–8, ovate, subequal, 9–18 mm × (7–)8–11 mm, straw-coloured; peduncles slender; spikes not clearly distinguishable from each other, linear to elliptical, up to 10 mm × 5 mm; spicoid bracts glumaceous, lanceolate, 2–8 mm × 1–2 mm. Spicoid (pseudo-spikelet) composed of 4 floral bracts, 2 staminate flowers and a terminal female flower; lower 2 bracts linear-lanceolate, 5–8 mm long, rounded at the apex; upper 2 bracts narrowly linear, 5–8 mm long, obtuse; staminate flowers with 1 stamen; female flower with 2 stigmas. Fruit obovoid, 1–1.5 mm × c. 1 mm, black, exocarp hard and weakly tuberculate, 1-seeded. Seed small.

Mapania linderi flowers in March–October. Pollination is probably by insects.

Mapania comprises c. 85 species, and is distributed throughout the tropics and subtropics and extending into warm temperate regions.

Ecology *Mapania linderi* occurs at 80–500 m altitude in humid and shaded locations in riverine forest, montane forest and secondary forest, often in valley bottoms. It is locally common.

Management *Mapania linderi* is only collected from the wild.

Genetic resources and breeding Although *Mapania linderi* has a relatively limited distribution, it is locally common and there are no indications that the species is threatened with genetic erosion.

Prospects *Mapania linderi* is only locally used for thatching, and its importance is unlikely to increase.

Major references Burkill, 1985; Lorougnon, 1972; Nelmes, 1951; Poorter et al., 2004; Simpson, 1992.

Other references Dai et al. (Editors), 2010; Hooper & Napper, 1972; Nelmes & Baldwin, 1952; Simpson & Inglis, 2001.

Authors M. Brink

MARANTOCHLOA CONGENSIS (K.Schum.) J.Léonard & Mullend.

Protologue Bull. Soc. Roy. Bot. Belg. 83: 17 (1950).

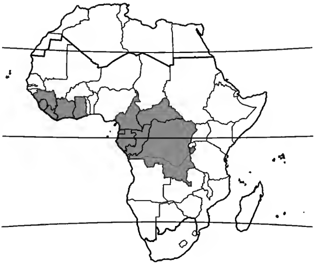
Family Marantaceae

Vernacular names Yoruba soft cane (En).

Origin and geographic distribution *Marantochloa congensis* is distributed from Guinea and Sierra Leone to the Central African Republic, DR Congo, Burundi and Cabinda (Angola).

Uses The stem and the stem bark are widely used for making cords and for plaiting mats, baskets and ornamental items. The petioles are also recorded to be used for tying and plaiting. The leaves are used for packing. In DR Congo the plants are laid on the ground to sleep on them. In DR Congo the dried stem is used as firebrand.

In traditional medicine in Côte d'Ivoire the leaves are chewed and the extract is swallowed for the treatment of diarrhoea, and a sauce of the leaves ground with palm nuts and meat is eaten against palpitation. In Congo the root sap is taken as a purgative and the leaves form part of a preparation drunk in case of painful and abundant menstruation.



Marantochloa congensis – wild

Properties Cords made from the stem bark are strong, but mats and baskets are not durable, because the bark strips lose their flexibility rapidly and tend to break readily when dry.

Botany Perennial, erect or scrambling herb up to 4 m tall, with rhizome; stems branched. Leaves alternate, antitropic (broader side of blade alternately to the right and to the left); petiole sheathing at the base, the uncalloused and calloused parts of the petiole not separated by a joint, uncalloused part of petiole up to c. 5 mm long, apical calloused part 2–7(–10) mm long and often hairy, transition of the petiole into the midvein marked by a beak on the upper surface, but continuous on the under surface; blade asymmetric, up to 20 cm × 10 cm, base rounded, apex acuminate, with the acumen usually not in line with the midvein. Inflorescence lax, c. 10 cm long, not or little branched, with at the nodes persistent abaxial bracts 1–2 cm long with 2-flowered cymules; cymule backed by an adaxial bract, peduncle c. 2 cm long. Flowers bisexual, zygomorphic, white or yellow; pedicel up to 5 mm long; bracteole absent; sepals free, equal, 3–4 mm long; corolla c. 5 mm long, tubular below, with 3 lobes; staminodes and stamen in 2 cycles, at the base forming a tube fused to the corolla tube, outer cycle consisting of 2 petaloid staminodes, inner cycle consisting of 1 stamen and 2 staminodes, of which 1 hooded with a cushion-like appendage; ovary inferior, densely hairy, 3-locular. Fruit a dehiscent, globose capsule, 3-lobed, smooth, with deciduous withered perianth. Seeds with a basal aril.

Flowers are pollinated by bees. Fruit production is low, but compensated by vigorous vegetative reproduction via rhizomes and adventive shoots in leaf axils and inflorescence.

Marantochloa comprises c. 15 species, distributed in the more humid parts of tropical Africa. It is closely related to *Ataenidia*. *Marantochloa cordifolia* (K.Schum.) Koechlin is a perennial herb up to 2 m tall, distributed in Cameroon, Gabon, Congo and Cabinda (Angola). The bark of its stem or petiole is used for making cords and for weaving mats, baskets and knife sheaths, and the pith is made into brooms. The species is sometimes planted in Cameroon. *Marantochloa monophylla* (K.Schum.) D'Orey (synonym: *Marantochloa holostachya* (Baker) Hutch.) is a perennial herb up to 2 m tall, with a stem bearing only 1–2 leaves. It is distributed in Nigeria, Cameroon, the Central African Republic, Equatorial Guinea, Gabon, Congo, DR Congo and Cabinda (Angola). Its leaves are used for wrapping food for cooking; they are said to give a good smell to the food. In Gabon the leaves are used as stoppers in calabashes. In DR Congo the midvein of the leaf is used for fishing crabs. In traditional medicine in DR Congo the powder of dried leaves is rubbed into scarifications on the belly of a woman to facilitate pregnancy. In DR Congo *Marantochloa monophylla* is sometimes planted in fields with other crops, to increase their yield.

Ecology *Marantochloa congensis* occurs from sea-level up to 1200 m altitude in moist, shaded locations in forest, including primary forest, secondary forest, riverine forest, swamp forest, gallery forest, seasonally flooded forest, mixed forest and forest regrowth.

Genetic resources and breeding In view of its wide distribution and vigorous vegetative reproduction, *Marantochloa congensis* is unlikely to be threatened with genetic erosion.

Prospects *Marantochloa congensis* is a widely used local source of material for tying, plaiting and wrapping. No information is available on local trade of its products, and there are no reports of the species being overexploited, but the plant may have potential for cultivation, and research on propagation and management practices may thus be worthwhile.

Major references Burkill, 1997; Dhetchuvi, 1996b; Koechlin, 1965; Tanno, 1981; Terashima & Ichikawa, 2003.

Other references d'Orey, 1981; Hattori, 2006; Hawthorne & Jongkind, 2006; Hepper, 1968c; Ley, 2008; Lubini, 1994; Neuwinger, 2000; Pischtschan, Ley & Claßen-Bockhoff, 2010; Terashima, Ichikawa & Sawada, 1988; Terashima, Kalala & Malasi, 1991.

Authors M. Brink

MARANTOCHLOA CUSPIDATA (Roscoe) Milne-Redh.

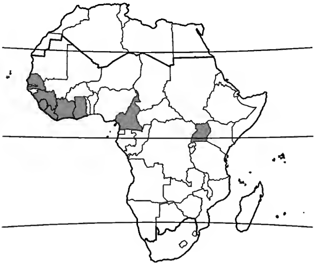
Protologue Proc. Linn. Soc. London 165: 30 (1954).

Family Marantaceae

Synonyms *Marantochloa flexuosa* (Benth.) Hutch. (1936).

Origin and geographic distribution *Marantochloa cuspidata* is distributed from Senegal to Ghana. It has also been recorded for Cameroun and Uganda.

Uses The leaves are used for packaging and for wrapping food and kola nuts. In Sierra Leone the leaf is folded into a cone to be used as a receptacle for honey collection, and in Ghana it



Marantochloa cuspidata – wild

has been used as a collecting device in rubber tapping. In Ghana the leaves are used for thatching.

Production and international trade In Ghana leaves gathered from the wild are sold in local markets.

Botany Perennial herb up to 2 m tall, with rhizome; stems erect, little branched, generally bearing only 1 or 2 leaves, and with imbricate, bladeless sheaths at the base. Leaves alternate, petiole sheathing at the base, 15–20 cm long including sheath, the uncalloused and calloused parts of the petiole not separated by a joint, apical calloused part 1–1.5 cm long, transition of the petiole into the midvein marked by a beak on the upper surface, but continuous on the under surface; blade triangular-lanceolate to ovate or oblong, asymmetric, up to 40 cm × 26 cm, base rounded, truncate or cuneate, apex acuminate, with the acumen not in line with the midvein, lower surface with hairy midvein. Inflorescence terminal, composed of 1 or more racemes; abaxial bracts 2.5–4 cm long with 1–2 cymules; cymule 2-flowered, with adaxial bract; peduncle as long as bract. Flowers bisexual, zygomorphic, yellow; pedicel up to 10 mm long; bracteole absent; sepals free, equal, scarious; corolla up to 20 mm long, tubular below, with 3 lobes; staminodes and stamen in 2 cycles, at the base forming a tube fused to the corolla tube, outer cycle consisting of 2 petaloid staminodes, inner cycle consisting of 1 stamen and 2 staminodes, of which 1 hooded with a cushion-like appendage; ovary inferior, hairy, 3-locular. Fruit a globose capsule. Seeds arillate.

Marantochloa comprises c. 15 species, distributed in the more humid parts of tropical Africa. It is closely related to *Ataenidia*.

Ecology *Marantochloa cuspidata* occurs in the undergrowth of humid forest, often secondary forest, or near rivers in savanna regions.

Genetic resources and breeding There are no indications that *Marantochloa cuspidata* is threatened by genetic erosion.

Prospects *Marantochloa cuspidata* is a useful local source of leaves for wrapping and thatching, locally sold in markets. There are no reports of the species being overexploited, but the plant may have potential for cultivation, and research on propagation and management practices may be worthwhile.

Major references Burkill, 1997; Dhetchuvi, 1996b; Hawthorne & Jongkind, 2006; Hepper, 1968c; Koechlin, 1965.

Other references Andersson & Chase, 2001; Owusu-Yeboah, 1993; Pischtschan, Ley & Claβen-Bockhoff, 2010; Prince & Kress, 2006a; Thomas, 1959; Tomlinson, 1961.

Authors M. Brink

MARANTOCHLOA LEUCANTHA (K.Schum.) Milne-Redh.

Protologue Bull. Soc. Roy. Bot. Belg. 83: 19 (1950).

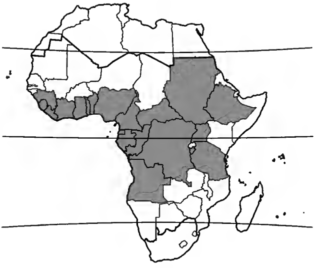
Family Marantaceae

Chromosome number $2n = 26, 28$

Vernacular names Yoruba soft cane (En).

Origin and geographic distribution *Marantochloa leucantha* is distributed from Guinea and Sierra Leone eastward to Ethiopia and southward to Angola.

Uses The stems are often used for plaiting



Marantochloa leucantha – wild

mats, baskets and traps. They are also used in fences, as a binding material in hut-building, and as base material for building mud walls. In Cameroon the bark is used for making cords and for weaving mats, baskets and knife sheaths, and the pith is made into brooms. The leaves are often used for thatching, for wrapping, especially food for cooking and kola nuts, and for lining carrying baskets. In Sierra Leone the leaf is folded into a cone to be used as a receptacle for honey collection. In Cameroon the leaves are used as fans. The petioles are used for making fishing nets. In Ghana sewing thread is obtained from the petioles, and in Nigeria veins from the leaf yield a thread.

In Nigeria the plants are browsed by goats and sheep. The fruit pulp is edible.

Marantochloa leucantha is widely used in African traditional medicine. In Côte d'Ivoire the root pulp is used as a dressing on abscesses, chancres and glandular swellings to soothe pain and to promote cicatrization. The leaf sap is drunk against epilepsy and madness, or pulverized leaves are taken in water or palm wine. For the treatment of bronchitis and cough the pulverized seeds are steeped in palm wine and the liquid is drunk or made into pellets and eaten. In Ghana the flowers are chewed for the treatment of stomach-ache and intestinal disorders, and the fruit or seed is swallowed to prevent boils. In the Central African Republic the plant is used for the treatment of skin mycosis. In DR Congo the leaves are rubbed on the body as a strengthening tonic before work. In Ethiopia preparations of the root and leaves are taken for the treatment of gonorrhoea. In Uganda and Tanzania root decoctions are drunk as an aphrodisiac, and in Tanzania sap squeezed from the rhizome is drunk as a galactagogue and rubbed into scarifications on the forehead and temples against headache.

Properties In Nigeria mats made from the stems are considered durable, but somewhat inflexible.

Adulterations and substitutes The stems and leaves of various other *Marantaceae*, particularly those of *Ataenidia conferta*, are used for similar purposes.

Description Perennial, erect or scrambling herb up to 4 m tall but often less, with rhizome; stems branched. Leaves alternate, homotropic (broader side of blade always to the right), petiole sheathing at the base, sheathing part up to 25 cm long, the uncalloused and calloused parts of the petiole not separated by a joint, uncalloused part of petiole up to 1 cm long, apical calloused part up to 2 cm long, transition of the petiole into the midvein marked by a beak on the upper surface, but continuous on the under surface; blade more or less ovate, asymmetric, up to 25 cm × 14 cm but often much smaller, base rounded, apex acuminate, with the acumen usually to the right of the midvein as seen from above, glabrous or hairy, lower surface whitish green or purplish. Inflorescence a panicle up to 40 cm long, lax, much branched, each branch with c. 4 nodes, with at each node a caducous abaxial bract 2.5–3.5 cm long with 1 cymule, rachis and bracts green; cymule 2-flowered, backed by a an adaxial bract, peduncle up to 3 cm long. Flowers bisexual, zygomorphic, c. 7 mm long, white to pink; pedicel up to 10 mm long; bracteole absent; sepals free, equal, c. 4 mm long, scarious; corolla 8–10 mm long, tubular below, with 3 lobes; staminodes and stamen in 2 cycles, at the base forming a tube fused to the corolla tube, outer cycle consisting of 2 petaloid staminodes, inner cycle consisting of 1 stamen and 2 staminodes, of which 1 hooded with a cushion-like appendage; ovary inferior, short-hairy, 3-locular. Fruit a subglobose capsule c. 9 mm in diameter, with conspicuous sutures, glabrescent, glossy, bright red, orange or creamy white, with deciduous withered perianth, not fleshy within, 3-seeded. Seeds shaped like a one-third segment of a sphere, 3–8 mm long, brown, grey or black, with a small basal aril.

Other botanical information *Marantochloa* comprises c. 15 species, distributed in the more humid parts of tropical Africa. It is closely related to *Ataenidia*.

Marantochloa mannii (Benth.) Milne-Redh. is a perennial herb up to 3 m tall, distributed from Côte d'Ivoire to DR Congo, Ethiopia, Uganda and Tanzania. The split stem and stem bark are used for plaiting mats and baskets. The leaves are used for thatching in Ghana, and for cooking food in Gabon. In Cameroon its use as a fibre plant is similar to that of *Marantochloa leucantha*. *Marantochloa ramosissima* (Benth.) Hutch. is a perennial herb up to 2.5 m tall, distributed in Côte d'Ivoire, Nigeria, Cameroon and Bioko (Equatorial Guinea), and also recorded from Sierra Leone and Liberia. It resembles *Marantochloa leucantha* and has much the same uses.

Growth and development The flowers are pollinated by bees.

Ecology *Marantochloa leucantha* occurs from sea level up to 1500 m altitude in primary and secondary forest, often in moist places. Its habitats include gallery forest, swamp forest, periodically inundated forest, fallows and roadsides in forest.

Propagation and planting *Marantochloa leucantha* is usually collected from the wild, but in Sierra Leone the plant is grown in the outskirts of town.

Harvesting The leaves are individually harvested by cutting the petiole at its base.

Handling after harvest The usual preparation for mat-making is to split the stems, remove the central pith and to dry the split stems in the sun. The stems are sometimes dyed before being used.

Genetic resources *Marantochloa leucantha* is not threatened with genetic erosion. Wild stands are usually durably exploited.

Prospects The stems of *Marantochloa leucantha* are widely used for plaiting and in construction, and the leaves for thatching and wrapping, and the plant is widely used in traditional medicine. It is occasionally planted and may have potential for wider cultivation. Therefore, research on propagation and management practices seems worthwhile.

Major references Bouquet & Debray, 1974; Burkill, 1997; Dhetchuvi, 1996b; Hattori, 2006; Hawthorne & Jongkind, 2006; Koechlin, 1965; Lye, 1994; Lye & Friis, 1997; Milne-Redhead, 1952; Neuwinger, 2000.

Other references Abbiw, 1990; Addo-Fordjour et al., 2008; Andersson & Chase, 2001; Cunningham, 1996; d'Orey, 1981; Giday, Asfaw & Woldu, 2010; Hamill et al., 2003; Hepper, 1968c; Kawukpa & Angoyo, 1994; Kokwaro, 1993; Ley & Claβen-Bockhoff, 2009; Missouri Botanical Garden, undated; Muhwezi, Cunningham & Bukenya-Ziraba, 2009; Neuwinger, 1998; Onwuka, Taiwo & Adu, 1992; Pischtschan, Ley & Claβen-Bockhoff, 2010; Prince & Kress, 2006a; Terashima, Kalala & Malasi, 1991; Van der Veen & Bodinga bwa Bodinga, undated; Wild & Mutebi, 1996.

Authors V.A. Kémeuzé

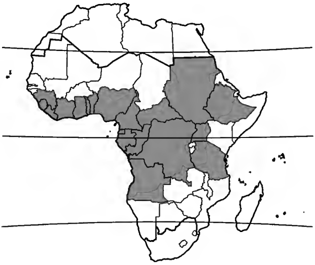
MARANTOCHLOA PURPUREA (Ridl.) Milne-Redh.

Protologue Bull. Soc. Roy. Bot. Belg. 83: 21 (1950).

Family Marantaceae

Vernacular names Yoruba soft cane (En). Canne molle (Fr).

Origin and geographic distribution *Marantochloa purpurea* is distributed from Guinea and Sierra Leone eastward to Ethiopia and southward to Angola.



Marantochloa purpurea – wild

Uses The stems are widely used for plaiting mats, baskets and traps. In Cameroon the bark is used for making cords and for weaving mats, baskets and knife sheaths, and the pith is made into brooms. In DR Congo the bark is split into narrow bands which are used for plaiting articles such as mats and traps. The leaves are often used for wrapping. In West Africa they are especially used for wrapping kola nuts to prevent desiccation and ease handling; in Cote d'Ivoire *Marantochloa purpurea* is known as 'la feuille de kola'. In Central Africa they are commonly used for wrapping cassava cakes. In Cameroon the leaves are also used for thatching, as cushion under sleeping mats and for making articles such as instant containers, cups, plates, pots, funnels, fans and parasols.

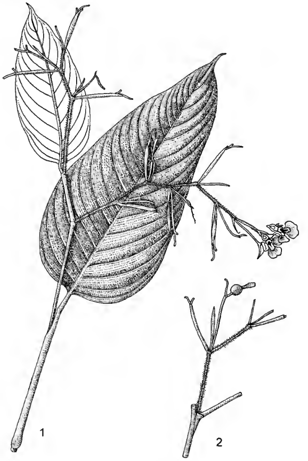
In traditional medicine in Côte d'Ivoire the root pulp is used as a dressing on abscesses, ulcers and glandular swellings to relieve pain and to promote cicatrization. The leaf sap is drunk against epilepsy and madness, and a leaf decoction for the treatment of stomach disorders. For the treatment of bronchitis and cough the pulverized seeds are steeped in palm wine and the liquid is drunk or made into pellets and eaten. In DR Congo the powdered root or crumpled leaves are applied on the bites of centipedes.

Production and international trade The leaves are sold in local markets, e.g. in the Central African Republic.

Properties In DR Congo the leaves are said to be apt to tear and become fragile as they dry, and therefore they are used less often than those of *Ataenidia conferta* (Benth.) Milne-Redh. Tests for the presence of alkaloids, flavonoids, saponins, quinones, tannins and terpenes all gave negative results.

Adulterations and substitutes The stems and leaves of various other *Marantaceae*, particularly those of *Ataenidia conferta*, are used for similar purposes.

Description Perennial, erect or scrambling herb up to 5 m tall, with rhizome; stems much branched. Leaves alternate, homotropic (broader side of blade always to the right); petiole sheathing at the base, sheathing part up to 42 cm long, uncalloused part of petiole up to 38 cm long, apical calloused part up to 6 cm long, the uncalloused and calloused parts of the petiole not separated by a joint; transition of the petiole into the midvein marked by a beak on the upper surface, but continuous on the under surface; blade more or less ovate, strongly asymmetric, up to 50 cm × 21 cm but often much smaller, base rounded, apex acuminate, with the acumen usually to the right of the midvein as seen from above, glabrous, sometimes pruinose or purplish below. Inflorescence lax, up to 45 cm long, branched, each branch with c. 4 nodes, with at each node an abaxial bract 2.5–4 cm long enveloping 2 cymules, rachis and bracts pink; cymule 2-flowered, backed by an adaxial bract, peduncle 3–3.5 cm long. Flowers bisexual, zygomorphic, c. 18 mm long, pink to purple; pedicel up to 10 mm long; bracteole absent; sepals free, equal; corolla tubular below, with 3 lobes; staminodes and stamen in 2 cycles, at the base forming a tube fused to the corolla tube, outer cycle white, consisting of 2 petaloid staminodes, inner cycle yellow, consisting of 1 stamen and 2 staminodes, of which 1 hooded with a cushion-like appendage; ovary inferior, short-hairy, 3-locular. Fruit a subglobose capsule c. 8 mm in diameter, 3-lobed, with conspicuous sutures, smooth or slightly hairy, bright red, with persistent withered perianth, not fleshy within, 3-seeded. Seeds shaped like a one-third segment of a sphere, 5–6 mm long, smooth, brown, with a small, whitish aril.



Marantochloa purpurea – 1, part of flowering plant; 2, infructescence.
Redrawn and adapted by Achmad Satiri Nurhaman

Other botanical information *Marantochloa* comprises c. 15 species, distributed in the more humid parts of tropical Africa. It is closely related to *Ataenidia*.

Growth and development In Benin flowering has been recorded in March and May, and fruiting in February, March, May and August. The flowers are pollinated by bees.

Ecology *Marantochloa purpurea* occurs at 200–1500 m altitude in moist locations in primary and secondary forest, including gallery forest, swamp forest, seasonally flooded forest, sometimes on roadsides in moist forest

Management *Marantochloa purpurea* is usually collected from the wild. In Guinea it is sometimes preserved and transplanted into gallery forest and near swamps for its usefulness in basket-making.

Harvesting In Central Africa the leaves are harvested from the forest and brought fresh to the market on a daily basis.

Genetic resources In view of its wide distribution and occurrence in a range of habitats, *Marantochloa purpurea* is unlikely to be threatened with genetic erosion.

Prospects The stems of *Marantochloa purpurea* are widely used for plaiting and tying, and the leaves for wrapping and thatching. The plant is locally preserved and planted, and leaves are commonly sold on local markets. Therefore, research on propagation and management practices for further domestication seems worthwhile.

Major references Dhetchuvi, 1996b; Fairhead & Leach, 1996; Hattori, 2006; Hawthorne & Jongkind, 2006; Koechlin, 1965; Lye, 1994; Lye & Friis, 1997; Milne-Redhead, 1952.

Other references Abbiw, 1990; Akoègninou, van der Burg & van der Maesen, 2006; Andersson & Chase, 2001; Bouquet & Debray, 1974; d'Orey, 1981; Hepper, 1968c; Letouzey, 1982b; Ley & Claβen-Bockhoff, 2009; Neuwinger, 2000; Pischtschan, Ley & Claβen-Bockhoff, 2010; Prince & Kress, 2006a; Sunderland & Obama, 1999; Tanno, 1981; Terashima & Ichikawa, 2003; Terashima, Kalala & Malasi, 1991; Visser, 1975.

Sources of illustration Mangenot, 1965.

Authors R.B. Jiofack Tafokou

MEGAPHRYNIUM MACROSTACHYUM (Benth.) Milne-Redh.

Protologue Kew Bull. 1952: 170 (1952).

Family Marantaceae

Chromosome number $2n = 28$

Synonyms *Sarcophrynium macrostachyum* (Benth.) K.Schum. (1902), *Sarcophrynium arnoldianum* De Wild. (1904).

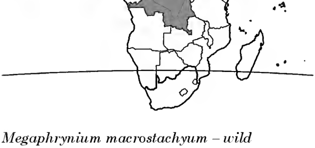
Vernacular names Yoruba soft cane (En).

Origin and geographic distribution *Megaphrynium macrostachyum* is distributed from Guinea and Sierra Leone to DR Congo, Cabinda (Angola), Sudan and Uganda.

Uses The leaves are much used for wrapping food, packing and thatching. In Central Africa, for instance, they are often used for wrapping cassava sticks before cooking. The leaves are made into a range of other articles, such as disposable baskets, plates, cups, pots, containers, funnels, fans and parasols, and they are used as cushion under sleeping mats. In Gabon the leaves are used for wrapping clothes to keep them dry in the rain. In DR Congo they are used for covering clay walls. The entire or split petiole and strips from its bark are used for tying and for making mats, baskets, brooms and other utensils. It is also made into bracelets and other ornaments.

Young leaves are cooked with oil and water and eaten as a vegetable. The fruit pulp is eaten and used as a sweetener in food preparation. The fruits are also used to wean babies. The roasted seeds are eaten in DR Congo; they are said to taste like maize.

In traditional medicine in Cote d'Ivoire, the leaf sap is drunk for the treatment of epilepsy and madness, and the leaves and fruits are sometimes prescribed as an antidote for poisonings. In Cameroon a leaf decoction is taken against jaundice. In DR Congo the root ash is applied on pustules.



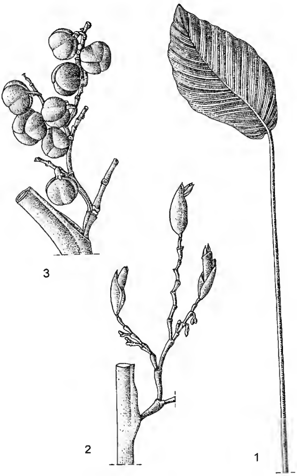
Megaphrynium macrostachyum – wild

Production and international trade The leaves and petioles are important in village life and are often traded in Central African markets. Bunches of leaves to be used for food wrapping were sold at prices ranging from US$ 0.22 to US$ 0.88 in markets of various towns in DR Congo in 2006, and baskets made from *Megaphrynium macrostachyum* at prices of US$ 0.22 to US$ 0.66. The high and increasing demand for cassava sticks in Central Africa means that there is a high consumption of *Megaphrynium macrostachyum* leaves as well, as at least two leaves are needed to wrap one stick. In Kisangani (DR Congo) it was recorded in 2008 that young leaves are often sold out early in the morning and consumers complain of the lack of supply.

Properties The leaves of *Megaphrynium macrostachyum* and other *Marantaceae* are said to give a special taste to the food wrapped in them, which is why they are preferred above banana leaves. It has also been recorded, however, that the leaves are not preferred for wrapping food by the Lega people in DR Congo, because they are said to be burnt easily.

Adulterations and substitutes The leaves of a range of other *Marantaceae* species are similarly used for wrapping and thatching.

Description Perennial herb up to 4 m tall, with rhizome up to 6 m long, stems bearing an inflorescence and a single subtending leaf, and numerous leaves arising directly from the rhi-



Megaphrynium macrostachyum – 1, leaf; 2, inflorescence; 3, infructescence.
Redrawn and adapted by Achmad Satiri Nurhaman

zome. Leaves with petiole up to 5 m long, sheathing at the base, apical calloused part 7–15 cm long, transition of the petiole into the midvein marked by a V-shaped beak on the upper surface, but continuous on the under surface; blade ovate-elliptical, more or less symmetric, 30–60(–90) cm × 12–30(–40) cm, base rounded to attenuate, apex acute or shortly acuminate. Inflorescence terminal, arising 10–33 cm below the calloused part of the petiole, up to 25 cm long, branched, the branches spike-like and articulate with numerous nodes and at each node an abaxial, caducous bract enveloping a single cymule; cymule 2-flowered, backed by a an adaxial, caducous bract, short-pedunculate, the flowers side by side with a fleshy bracteole c. 2.5 mm long between them. Flowers bisexual, zygomorphic, c. 2 cm in diameter, white, tinged yellow or orange; sepals free, equal, c. 4 mm long, glabrous, yellow to bluish purple; corolla 8–10 mm long, tubular below, with 3 lobes, white to bluish purple, towards the tip yellow; staminodes and stamen in 2 cycles, at the base forming a tube fused to the corolla tube, outer cycle consisting of 1–2 petaloid staminodes, inner cycle consisting of 1 stamen and 2 staminodes, of which 1 hooded with a sword-like appendage; ovary inferior, glabrous, 3-locular. Fruit depressed globose, 2–2.5 cm in diameter, 3-lobed, with conspicuous sutures, smooth, bright red, with white pulp inside, normally 3-seeded. Seeds c. 15 mm × 10 mm, purple, bluish violet or black, with a deeply laciniate, whitish aril.

Other botanical information *Megaphrynium* comprises about 5 species distributed in the forest regions of tropical Africa. *Megaphrynium distans* Hepper is a perennial herb c. 1 m tall, distributed in Liberia, Côte d'Ivoire, Ghana and Equatorial Guinea. In Côte d'Ivoire the leaves are used for thatching, and in Ghana for wrapping meat. *Megaphrynium gabonense* Koechlin is a perennial herb 1–2 m tall, endemic to Gabon. Its leaves are used for thatching and for wrapping cassava, while its stems are used for making mats. The fruit pulp is edible. *Megaphrynium trichogynum* Koechlin is a perennial herb up to 2 m tall, distributed in Cameroun, the Central African Republic, Equatorial Guinea, Gabon, Congo and DR Congo. In Cameroon its leaves and petioles are used for similar purposes as those of *Megaphrynium macrostachyum*. In Congo the pulped stem is eaten with palm oil against dizziness and vomiting, and a decoction of the stem is drunk in case of a beginning hernia. *Megaphrynium velutinum* (Baker) Koechlin (synonym: *Sarcophrynium velutinum* (Baker) K.Schum.) is a perennial herb 1.5–2 m tall, distributed in Côte d'Ivoire, Cameroon, Equatorial Guinea, Gabon, Congo and DR Congo, and possibly in Liberia. Its leaves are used for thatching.

Growth and development *Megaphrynium macrostachyum* produces a dense leaf layer and resprouts rapidly from rhizomes after disturbance; as a result the plant competes successfully with other plants. The flowers are pollinated by bees.

Ecology *Megaphrynium macrostachyum* occurs from sea level up to 1500 m altitude in wet locations in primary and secondary forest and fallow land. *Megaphrynium macrostachyum* often occurs in large, monodominant thickets, which appear to be capable of delaying tree regeneration in forest gaps. It often reaches high densities after logging, shifting cultivation or fire, and represents an important stage of succession in Central African rain forests, most notably in areas of savanna reintrogression or old secondary vegetation, but also at much smaller scales such as forest gaps. In Central Africa the vegetative parts of *Megaphrynium macrostachyum* are an important food of gorillas, chimpanzees and bonobos.

Propagation and planting Plants reproduce rapidly and abundantly, by sprouting from rhizomes and by seed.

Management *Megaphrynium macrostachyum* is usually collected from the wild, but is sometimes planted. In Nigeria *Megaphrynium macrostachyum* is sometimes found in cocoa intercropping systems.

Harvesting In Equatorial Guinea the leaves are harvested from the forest and brought fresh to the markets each day.

Handling after harvest To obtain material for tying in DR Congo, the petiole is drawn vigorously back and forth several times on a tree stem to change it into a flat, flexible cord.

Genetic resources In view of its wide distribution, common occurrence and rapid regeneration, *Megaphrynium macrostachyum* seems not in danger of genetic erosion, although locally overexploitation may take place. It Gabon, for instance, it has been recorded that the leaves are so much exploited, that the plants can only be found far away from houses.

Prospects *Megaphrynium macrostachyum* is useful local source of leaves for wrapping and thatching. As the leaves are in high demand and locally overexploited, the species seems to have potential for cultivation, and research on propagation and management practices is worthwhile.

Major references Burkill, 1997; Hattori, 2006; Hepper, 1968c; Koechlin, 1965; Latham, 2004; Milne-Redhead, 1952; Terashima & Ichikawa, 2003; Thomas et al., 1989; Toirambe Bamoninga, 2007; White et al., 1995.

Other references Betti & Lejoly, 2009; Bouquet, 1969; Brncic, 2002; Cabezas et al., 2005; de Rouw, 1993; Hepper, 1968d; Lubini, 1994; Missengoula, 2004; Neuwinger, 2000; Nkeoua & Boundzanga, 1999; Oladokun, 1990; Pischtschan, Ley & Claßen-Bockhoff, 2010; Raponda-Walker & Sillans, 1961; Sunderland & Obama, 1999; Tchatat, 1999; Tehe, 1986; Terashima, Kalala & Malasi, 1992; Termote, Van Damme & Dhed'a Djailo, 2010; Van Damme & Termote, 2008; Yembi, 1999.

Sources of illustration Koechlin, 1965; White & Abernethy, 1997.

Authors R.B. Jiofack Tafokou

MEGISTOSTEGIUM NODULOSUM (Drake) Hochr.

Protologue Annuaire Conserv. Jard. Bot. Genève 18/19: 228 (1915).

Family Malvaceae

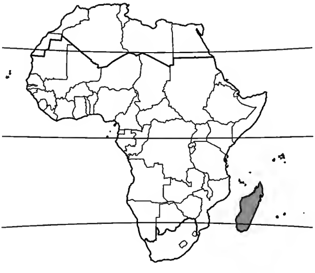
Synonyms *Hibiscus nodulosus* Drake (1903).

Origin and geographic distribution *Megistostegium nodulosum* is endemic to Madagascar, where it is restricted to the southern part of the country.

Uses The bark fibre of *Megistostegium nodulosum* is used for textiles. The strong wood is used as beams in house construction, for the production of charcoal for cooking and as a torch for fishing at night. Pegs are made from the wood for joining wood in boat building. The powdered bark is used for relieving eye ailments.

Properties The leaves of *Megistostegium nodulosum* are rich in phenolics, whereas alkaloids are absent.

Botany Small tree up to 8 m tall. Leaves alternate, simple; stipules filiform; petiole short; blade rounded, greyish green, up to 4 cm long, base cordate, margin entire or sparsely toothed towards the apex, both sides densely white pubescent, palmately veined at base, penninerved above. Flowers axillary, solitary, erect, bisexual, 5-merous; epicalyx bell-shaped, petal-like, red, thin; calyx of reduced sepals, fused at base; petals red, shorter than the involucre, not overlapping each other, at base fused to staminal column; stamens numerous, fused into a column, exerted, up to 5 cm long, curved; ovary superior, 5-locular, each locule with 2 ovules, style with 5 branches. Fruit a dry, globose capsule, dehiscent, locules 1-seeded.



Megistostegium nodulosum – wild

Megistostegium nodulosum flowers throughout the year with peaks from November through mid-March and from August through September.

Megistostegium comprises 3 species endemic to Madagascar. The species partly overlap in distribution and hybridization seems to occur.

Ecology *Megistostegium nodulosum* is restricted to sandy soils of the dry, deciduous scrublands of southern Madagascar and its coastline. It can tolerate high salt concentrations.

Genetic resources and breeding *Megistostegium nodulosum* is relatively widely distributed and occurs inside three protected areas. Even so, its conservation status is classified as 'Near Threatened', as populations will become reduced in size as a result of its popularity as a source of timber, fuelwood and medicines. All species of the genus face threats, even within protected areas, from browsing goats and other livestock, by invasive plants that compete for available water (e.g. *Opuntia* spp.) and the (potential) extinction of pollinators.

Prospects Measures to prevent genetic erosion of *Megistostegium nodulosum* and its congeners (in-situ and ex-situ conservation) should be considered. Research into husbandry measures for optimal use as an ornamental could be worthwhile.

Major references Decary, 1946; Hochreutiner, 1955; Koopman, 2011.

Other references Boiteau, Boiteau & Allorge-Boiteau, 1999; Schatz, 2001; Simmen et al., 1999.

Authors C.H. Bosch

MERREMIA AEGYPTIA (L.) Urb.

Protologue Symb. Antill. 4: 505 (1910).

Family Convolvulaceae

Chromosome number $2n = 28, 30$

Synonyms *Merremia pentaphylla* (L.) Hallier f. (1893).

Vernacular names Hairy woodrose (En). Corda de viola, jetirana, mata me embora, batatão roxo (Po).

Origin and geographic distribution *Merremia aegyptia* originates from Latin America but is now widespread throughout the tropics and is found in many tropical African countries.

Uses The stems are used for binding, for instance for frames in house building in Ghana. Some stock graze on the plant but horses do not. *Merremia aegyptia* causes diarrhoea in small stock when large quantities are eaten. In Nigeria the dried leaves are used as a dressing for burns.

Properties Chlorogenic and benzoic acids, as well as a metabolite of the latter (the glycoside 1,2,3,4-tetrahydro-β-carboline-3β-carboxylic acid), have been isolated from *Merremia aegyptia*.

Botany Annual herb up to 6 m tall; stems slender, twining, long-hirsute. Leaves alternate, palmately compound with 5 leaflets; stipules absent; petiole 2.5–12 cm long; leaflets sessile, elliptical(-oblong), 2.5–12 cm × 1–4 cm, base acute, apex acuminate, margin entire, on both surfaces appressed hairy. Inflorescence a cyme, few to several-flowered; peduncle up to 22 cm long. Flowers bisexual, regular, 5-merous; pedicel up to 2.5 cm long; sepals unequal, the outer 3 ovate-lanceolate, 14–25 mm long, with coarse, stiff hairs, the inner 2 shorter, ovate, glabrous; corolla funnel-shaped, up to 3.5 cm long, white, glabrous; stamens inserted at 5 mm of the base of corolla tube, filaments unequal; ovary superior, 4-celled, style slender, c. 7 mm long, stigmas 2, round. Fruit a globose capsule 1.2–1.5 cm in diameter, apiculate, glabrous, pale brown, enclosed by persistent calyx, dehiscent by 4 valves, up to 4-seeded. Seeds trigonous, c. 4 mm long, brown, glabrous.

In Benin *Merremia aegyptia* flowers in July and from October to December.

Merremia comprises about 80 species, widely spread in the tropics. In tropical Africa about 32 species occur with several of them introduced as ornamentals or accidentally as weeds.

Ecology *Merremia aegyptia* occurs from sea-level up to 1500 m altitude. It is found in riverine vegetation, grassland, open deciduous woodland, *Combretum-Terminalia* woodland, open forest and as a weed in cultivated land.

Genetic resources and breeding The centre of diversity of *Merremia aegyptia* is in Latin America. Populations in tropical Africa are not threatened with genetic erosion.

Prospects *Merremia aegyptia* is of local importance only, and is unlikely to become more important in tropical Africa in the future. Further expansion of this introduced species should be avoided because it behaves as a weed.

Major references Burkill, 1985; Demissew Sebsebe, 2001; Gonçalves, 1987.

Other references Abbiw, 1990; Akoègninou, van der Burg & van der Maesen, 2006; Baumer, 1975; Bosser & Heine, 2000; Henrici, Ka-

loga & Eich, 1995; Muhammad Mansur, 2001.

Authors C.H. Bosch

MEZONEURON ANGOLENSE Welw. ex Oliv.

Protologue Fl. trop. Afr. 2: 261 (1871).

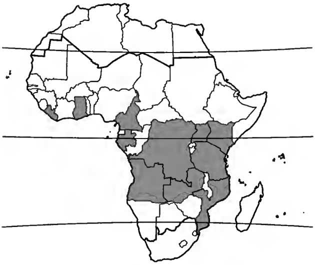
Family Caesalpiniaceae (Leguminosae - Caesalpinioideae)

Synonyms *Caesalpinia angolensis* (Welw. ex Oliv.) Herend. & Zarucchi (1990).

Origin and geographic distribution *Mezoneuron angolense* is distributed in West, Central, East and southern Africa.

Uses In DR Congo the bark is sometimes used for making cordage, although more recent reports from eastern DR Congo indicate that the plant is viewed as useless and troublesome because of its prickles. The plant is sometimes considered to have ornamental value.

Botany Liana up to 20 m long; stems 4–8 cm in diameter, sparsely hairy to almost glabrous, armed with scattered downwardly hooked prickles up to 11 mm long, which on older stems become enlarged and raised on subconical-cylindrical corky bosses up to 2 cm long and 1.5 cm in diameter. Leaves alternate, bipinnately compound with 4–10 pairs of opposite pinnae 4–8 cm long, each with 4–9 pairs of leaflets; stipules very small, caducous; petiole and rachis together (6–)10–30 cm long, rachis with paired hooked prickles, especially at base of pinnae; leaflets opposite, elliptical-oblong, (6–)10–28(–35) mm × (4–)6–15(–19) mm, the terminal ones usually broadly obovate and slightly larger, base rounded and oblique, apex rounded to emarginate, glabrous except usually on the midvein beneath and often also the basal part of the lower surface. Inflorescence a terminal or lateral raceme 5–40 cm long, simple or branched, hairy, many-flowered; bracts linear-triangular, 4–5 mm long, early caducous. Flowers bisexual, zygomorphic, 5-merous; pedicel 4–11 mm long; sepals imbricate, the lower one curving upwards over the others, unequal, oblong, 5–9 mm × 3–4 mm, hairy; petals imbricate, 6.5–9 mm × 5.5–7.5 mm, the lamina suborbicular and clawed, yellow or greenish yellow; stamens 10, alternately long and short, longest ones 13–17 mm long; ovary superior, 1-locular. Fruit an elliptical-oblong to narrowly elliptical, flattened pod 6.5–14.5 cm × (2–)2.5–4.5 cm including the large membranous wing on the upper margin, indehiscent, with the persistent receptacular disc forming a collar round the base, red-brown to brown-black, leathery, (1–)2–4(–5)-seeded. Seeds elliptical to oblong, compressed, 5–9 mm × 2.5–7 mm, smooth, blackish. Seedling with hypogeal germination.



Mezoneuron angolense – wild

Mezoneuron comprises about 20 species, mostly in tropical Asia and extending into Australia and Polynesia, with 2 species in mainland tropical Africa and 2 in Madagascar. It is sometimes included in *Caesalpinia* as subgenus *Mezoneuron*, but is distinguished by the thin, winged pods.

Ecology *Mezoneuron angolense* occurs from near sea-level up to 2000 m altitude, in rainforest, riverine and swamp forests, secondary forest, forest margins, coastal evergreen bushland, thickets, savanna, and along roads.

Genetic resources and breeding In view of its wide distribution and occurrence in a wide range of habitats, including disturbed ones, *Mezoneuron angolense* is not threatened by genetic erosion.

Prospects Although *Mezoneuron angolense* is widely distributed in tropical Africa, records of it being used as a fibre plant are scarce, and contradicted by other sources characterizing the plant as useless and troublesome. Therefore, the prospects of this plant seem very limited.

Major references Brenan, 1967a; Brummitt et al., 2007; Wilczek et al., 1952.

Other references d'Oliveira Feijão, 1963; Medina, 1959; Missouri Botanical Garden, undated; Yamada, 1999.

Authors M. Brink

MILLETTIA BARTERI (Benth.) Dunn

Protologue Journ. Bot. 49: 221 (1911).

Family Papilionaceae (Leguminosae - Papilionoideae, Fabaceae)

Chromosome number $2n = 20$

Synonyms *Lonchocarpus barteri* Benth. (1860).

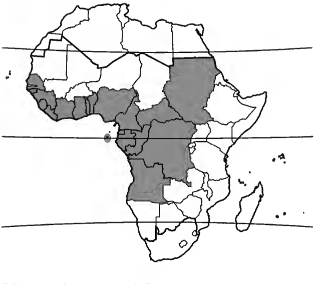
Origin and geographic distribution *Millettia barteri* is distributed in tropical and subtropical Africa; it has been reported from Senegal eastwards to Sudan and southwards to Angola.

Uses The main stems are very strong and used as cables for boats and hauling timber logs. In Ghana and DR Congo the stems are used for binding in house construction. Very strong fibres are extracted from the bark and are used to make animal traps. Stem fibre is sold for use as a sponge for scrubbing. The stem yields potable water when cut.

Ground twigs are macerated and subsequently drunk as a purgative. Powdered bark is taken as a snuff for headache and sinusitis in Côte d'Ivoire and Nigeria. Leaf sap is used topically for the treatment of inflammation of the ear, toothache, and filariasis in the eyes. To mature abscesses a dressing of pulped leaves is applied. Leaf pulp is rubbed on the skin in case of pulmonary complaints, bronchitis and stiffness. A root decoction is drunk to cure cardiac troubles. The pounded stem or twigs, finely cut stem, macerated bark and leaves are used as a fish poison.

Properties The seeds of *Millettia barteri* contain homoarginine and γ-hydroxyhomoarginine.

Botany Large liana over 30 m long, rarely a shrub or small tree; stem longitudinally ridged, up to 10 cm in diameter; bark thick, surface rough, furrowed with small and inconspicuous lenticels, purplish, glabrous; young twigs finely hairy. Leaves alternate, imparipinnately compound with 2–7 pairs of leaflets; stipules early caducous; petiole up to 12 cm long, rachis up to 13 cm long, yellow; stipels absent; petiolules 6 mm long; leaflets opposite, elliptical or elliptical-oblong, up to 15 cm × 8 cm, abruptly and obtusely acuminate at apex, sparsely hairy below. Inflorescence a terminal or axillary, slender panicle 15–60 cm long, with or without branches up to 16 cm long. Flowers bisexual, papilionaceous, scented; pedicel up to 2 mm long; calyx campanulate, 3–4 mm long, truncated; corolla pale pinkish to red, turning violet when ageing, standard orbicular, soft-hairy on the outside, 12–15 mm in diameter, wings and keel 8–10 mm long; stamens 10, 9 fused, 1 free; ovary superior, hairy, style slender, curved, hairy at base. Fruit a linear, flat pod 7 cm × 2 cm, with thickened margin, brown-hairy, indehiscent, 1–3-seeded. Seeds ovoid, flattened, 15–18 mm × 20–22 mm, smooth, dark brown.



Millettia barteri – wild

Millettia comprises about 150 species, most of them (about 90) in mainland Africa, 8 endemic to Madagascar, and about 50 in tropical Asia. It is in need of revision and should be split into several genera on the basis of molecular evidence.

The stems of *Millettia comosa* (Micheli) Hauman (synonym: *Millettia gagnepainiana* Dunn), a liana occurring in Gabon, Congo and western DR Congo, are used for tying in Gabon. A decoction of the twigs is gargled in case of toothache. In DR Congo the stems of both *Millettia macroura* Harms and *Millettia theuszii* (Büttn.) De Wild. are used for construction and for tying and both are important as bee forage.

Ecology *Millettia barteri* is restricted to river banks, swamp forest and temporarily flooded forest.

Genetic resources and breeding Since *Millettia barteri* is widespread and not heavily exploited there is no reason to assume the species will be threatened in the near future. Research is needed on the medicinal aspects to be able to assess its value in this respect.

Prospects Locally *Millettia barteri* will continue to be used as one of the strongest lianas available.

Major references Banzouzi et al., 2008; Burkill, 1995; de la Estrella et al., 2010; Hawthorne & Jongkind, 2006; Raponda-Walker & Sillans, 1961.

Other references Allen & Allen, 1981; Chevalier, 1937; Ewango, 2010; Hepper, 1958; Latham, 2005; Neuwinger, 2000; Noumi, 2004; Raponda-Walker, 1951; Southon et al., 1994; Van der Veen & Bodinga bwa Bodinga, undated.

Authors N. Nyunaï

MISCANTHUS JUNCEUS (Stapf) Pilg.

Protologue Engl. & Prantl, Nat. Pflanzenfam., ed. 2, 14: 113 (1940).

Family Poaceae (Gramineae)

Synonyms *Miscanthidium gossweileri* Stapf (1917), *Miscanthidium teretifolium* (Stapf) Stapf (1917), *Miscanthus teretifolius* (Stapf) Pilg. (1940).

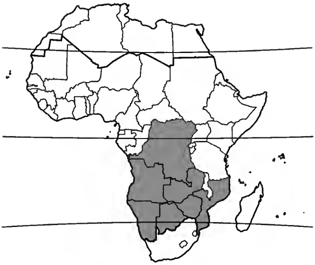
Vernacular names Wireleaf Daba grass (En).

Origin and geographic distribution *Miscanthus junceus* is distributed from DR Congo southward through southern Africa to Swaziland and South Africa.

Uses The stems are harvested for thatching and making fences. The leaves are generally too coarse for grazing.

Production and international trade *Miscanthus junceus* is only used and traded locally.

Botany Perennial, tufted grass with stems 1–3 m tall. Leaves alternate; ligule a ciliolate membrane; blade terete, 50–100 cm long, 1–3 mm in diameter, apex acuminate, midvein a slender yellow line on the adaxial surface. Inflorescence a linear to narrowly ovate panicle 20–50 cm long, bearing numerous racemes 2–8 cm long, with a tough, slender rachis. Spikelets in pairs, similar, pedicelled, lanceolate to narrowly oblong, 3–5 mm long, falling entire, 2-flowered; callus white-bearded, beard c. ¼ the length of the spikelet; lower glume oblong, as long as the spikelet, papery, 5-veined, surface flat, villous, apex 2-fid; upper glume lanceolate, 5-veined, surface villous, apex acute; basal floret sterile, without significant palea, lemma oblong, slightly shorter than spikelet, hyaline, 1-veined; upper floret bisexual, palea absent or minute, lemma lanceolate, 1–2 mm long, hyaline, 1-veined, margins ciliolate, apex 2-fid, with a geniculate awn 2–10 mm long, lodicules 2, stamens 3, ovary 1-locular, stigmas 2. Fruit a caryopsis (grain).



Miscanthus junceus – wild

In southern Africa *Miscanthus junceus* flowers in November–June.

Miscanthus is classified in the *Andropogoneae*. It comprises c. 20 species distributed in Africa and South-East Asia. On the basis of evidence from DNA analyses, it has been proposed to combine *Miscanthus junceus* with several other *Miscanthus*, *Saccharum*, *Miscanthidium* and an *Eryanthus* species into *Miscanthidium*. *Miscanthus junceus* would then become *Miscanthidium teretifolium* (Stapf) Stapf.

Ecology *Miscanthus junceus* always occurs in or near water, on riverbanks or in dambos or marshes, mostly in coarse sandy soils at 700–1400 m altitude. In the Okavango delta it is the most common grass in permanent water. Also in the North-Eastern Sandy Highveld in Mpumalanga (South Africa) it is dominant in shallow-water vegetation. The species plays an important role in riverbank protection and water purification.

Management *Miscanthus junceus* only grows wild.

Genetic resources and breeding As *Miscanthus junceus* is widespread and locally dominant it is not in danger of genetic erosion.

Prospects *Miscanthus junceus* is likely to remain of local importance as a source of material for thatching and fencing. Research into its potential as a plant for water purification and riverbank protection seems warranted.

Major references Clayton, Harman & Williamson, 2002–; Cope, 2002; van Oudtshoorn, 1999; van Wyk & Gericke, 2000.

Other references Bonyongo, Bredenkamp & Veenendaal, 2000; Burgoyne, Bredenkamp & van Rooyen, 2000; Ellery, McCarthy & Smith, 2003; Hodkinson et al., 2002; Ibaragi, 2004; Missouri Botanical Garden, undated.

Authors L.P.A. Oyen

MOMORDICA ANGUSTISEPALA Harms

Protologue Bot. Jahrb. Syst. 58: 239 (1923)

Family Cucurbitaceae

Synonyms *Momordica bracteata* Hutch. & Dalziel (1927).

Origin and geographic distribution *Momordica angustisepala* is distributed in the forest zone from Côte d'Ivoire to Cameroon.

Uses The stem of *Momordica angustisepala* is used as washing and bathing sponge in Ghana, Benin and Nigeria. After maceration, the stem is also used as filter for palm oil and palm wine. In Nigeria the stem is used for making woven masks for masquerades. The decorticated and washed twigs are chewed in Ghana. The root extract of *Momordica angustisepala* is used as an abortifacient in traditional medicine in South Nigeria.

Production and international trade The plant is sometimes cultivated in Ghana but no production or trade data are available.

Properties A root extract of *Momordica angustisepala* produced contractions on isolated guinea pig ileum similar to those of acetylcholine and histamine.

Botany A dioecious climber; stem more or less puberulous; tendrils unequally branched, bifid, spirally coiled with a straight part 4–6 cm long. Leaves alternate, simple; petiole 1.5–3.5(–5) cm long, puberulous or almost glabrous; blade broadly ovate or ovate-oblong, 5–12 cm × 4–9 cm, unlobed or 3–(5)-lobed, base cordate, apex acuminate or mucronate, margin often coarsely and acutely dentate, membranous, scabrid-puberulous on both surfaces. Flowers unisexual, regular, 5-merous; male flowers several together in more or less corymbose or subumbellate inflorescence; peduncle 3–6 cm long, puberulous or glabrescent, with a broadly ovate-cordate bract at the apex, bract 1.5–2.5 cm × 2–2.5 cm, margin entire or crenulate; pedicel 4–8 mm long; sepals lanceolate, 8–15 mm long, acuminate, brown or black; petals round, 5 mm in diameter, cream-coloured, yellow or orange, finely pubescent; stamens with bifid connectives, filaments 1 mm long, glabrous, anther 2.5 mm long with curved apex. Female flowers solitary; perianth similar to male flowers; ovary flask-shaped, pubescent. Fruit an ovoid berry up to 15 cm long, with a long beak, with ondulate ribs. Seeds black and slightly wrinkled.

The reproductive biology of the species is not well documented and requires further study. Reproductive organs are scarcely found and one may speculate that the plant preferentially reproduces vegetatively.

Momordica is a diverse genus comprising more than 47 species with most representatives in Africa. Common species in West and Central Africa thriving in the same distribution area include *Momordica charantia* L., *Momordica cissoides* Benth., *Momordica gilgiana* Cogn. and *Momordica foetida* Schum.

Ecology *Momordica angustisepala* is usually found in closed, deciduous and semi-deciduous forest. It also occurs at the edge of secondary forest or in old plantations, disturbed areas and roadsides.

Management The plant is sometimes cultivated, but stems are mainly harvested from the wild. Sponges are obtained by pounding the stem, washing out the impurities and drying.

Genetic resources and breeding *Momordica angustisepala* is rare in West Africa. The species is threatened by land clearance for agriculture or infrastructural development. Few accessions are maintained at the Botanical Garden of the University of Ife (Nigeria). Recent collecting missions carried out by the author from 2005 to 2008 in eight countries of West Africa resulted in only few herbarium specimens for this species.

Prospects If it can be more widely cultivated or sustainably harvested from wild stands, the plant is a good source of biological sponge for home use. The root contains oxytocic compounds which may be useful in the development of contraceptive methods in medicine.

Major references Burkill, 1985; Burkill, 2000; Keay, 1954c; Keraudren, 1967; Okoli, 1984.

Other references Abbiw, 1990; Achigan-Dako, 2008; Aguwa & Mittal, 1983; Akoègninou, van der Burg & van der Maesen, 2006; Irvine, 1961; Jeffrey, 1965; Jeffrey & de Wilde, 2006; Missouri Botanical Garden, undated; Osemeobo, 2005; Tuffour, 1997.

Authors E.G. Achigan-Dako

MUSA TEXTILIS Née

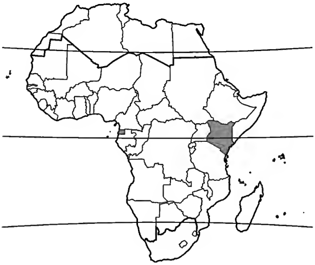
Protologue Anal. Cienc. Nat. 4: 123 (1801).

Family Musaceae

Chromosome number $2n = 20$

Vernacular names Abaca, abacá, Manila hemp (En). Abaca, chanvre de Manille, bananier à fibres (Fr). Cânhamo-de-manila (Po).

Origin and geographic distribution Abaca is native to the Philippines and northern Indo-



Musa textilis – planted

nesia. Until the 1920s little or no commercial cultivation existed outside of the Philippines, but since then it has been successfully cultivated in other South-East Asian countries as well as in Central America and Ecuador. In tropical Africa it has been grown in Cameroon, Equatorial Guinea (Bioko), Kenya, Uganda and Tanzania, but at present it seems to be grown in Equatorial Guinea and Kenya only.

Uses Abaca fibre extracted from the leaf sheath of *Musa textilis* is principally used for specialty papers and cordage. It has long been the preferred fibre for marine and fishing cordage due to its strength and resistance to saltwater, but this use has diminished with the advent of synthetic rope fibres. Nowadays the main use of abaca fibre is for pulp and paper. It is used for making a range of products including teabags, banknotes, filter paper, sausage casings, capacitor paper, cigarette paper, and the well-known Manila envelope paper (which was traditionally made from old abaca ropes). The fibre is suitable for textiles after it has been cottonized, a process in which fibre strands are cut to a uniform length so that they can be spun in cotton-spinning equipment. The fibre is used in high-end fabrics, particularly in blends with silk or pineapple fibre (*Ananas comosus* (L.) Merr.). Abaca fibre is also used in fibre crafts such as baskets, table mats, hammocks, bags and footwear. The fibre is finding increasing use in manufactured construction materials such as wallboards, floor and roof tiles, and as a reinforcing fibre in asphalt and concrete. It is also used in plastic composites in automobile bodies as a substitute for fibreglass reinforcement.

The dried entire outer leaf sheath is used in manufacturing ceiling boards and wallpaper, as well as for trays, baskets, wall panelling, and place mats. The inner leaf sheaths are used for roofing and for shading nursery seedlings, and as plates and food containers. Abaca ribbons are used as decorative and packaging material. The leaves are used as food wrapping, as animal fodder, or pulped for paper.

The sap of abaca is used in traditional Philippine medicine to treat wounds by inducing blood clotting.

Production and international trade According to FAO estimates the average annual world production of abaca fibre in 2001–2005 was about 99,000 t. Major producers were the Philippines with an average annual production of about 69,000 t (from an average area of about 120,000 ha) and Ecuador with about 28,000 t (from about 20,000 ha). Minor producers were Costa Rica (1100 t from 1100 ha), Indonesia (600 t from 600 ha), Equatorial Guinea (500 t from 1800 ha) and Kenya (30 t from an unknown area). The annual production in the Philippines was fairly stable, but in Ecuador the production increased from 25,000 t in 2001 to 29,000 t in 2005, and the estimated area under abaca increased from 17,000 ha in 2001 to more than 22,000 ha in 2005. The producer price per ton of abaca fibre in 2001–2005 increased from US$ 309 to US$ 596 in the Philippines, and from US$ 429 to US$ 583 in Ecuador. In the Philippines production is primarily by smallholders, while in Ecuador an estate system dominates.

The main exporter in 2001–2005 was the Philippines, with an average annual export of abaca products of 44,000 t, of which 15,000 t fibre, 7000 t cordage, 19,000 t pulp and 3000 t other products. The main importers were the United Kingdom and Japan.

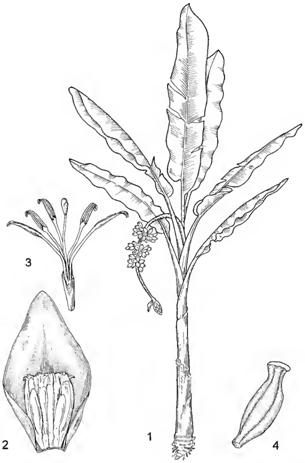
Properties The primary fibre (commercial grade) is obtained from the vascular bundles of the outer layer of the leaf sheath. The middle layer contains a small amount of weak secondary fibre, and the innermost layer contains no fibre. The fibre strands of commerce are 1–3.5 m long bundles of fibre cells. The ultimate fibre cells are (2–)4–8(–12) mm long and (6–)13–29(–53) μm in diameter, with a lumen width of (1–)7–14(–33) μm and a cell wall thickness of (1–)4.5(–16) μm. They taper gradually to a pointed or rounded end. Irregular ends are rare. In general the tips are much finer and more pointed than those of sisal (*Agave sisalana* Perrine). Very fine dislocations and cross-markings are often present. The cross-section of the fibre cells is an oval or a rounded polygon of 5–6 sides. Abaca fibre contains 55–64% α-cellulose, 18–23% hemicelluloses, 5–18% lignin, 1% pectin, and 1–3% ash.

Abaca fibre is classified among the hard fibres, like sisal. It is remarkable for its strength and resistance to fresh and salt water. It has a tensile strength of 850–1400 N/mm², an elongation at break of 8–12% and a modulus of elasticity of c. 72 GPa. It is three times as strong as cotton (*Gossypium* spp.) fibre, twice as strong as sisal, and also stronger than hemp (*Cannabis sativa* L.) and sunn hemp (*Crotalaria juncea* L.). It is more resistant to salt water than most other vegetable fibres. Commercial abaca fibre ranges from almost pure white, through cream to light or dark brown, depending on cultivar, position of the sheath in the pseudostem, and fibre extraction and processing.

Abaca fibre is excellent raw material for specialty papers. Compared to wood, the ultimate fibres are longer and finer, and abaca has lower lignin, ash, silica and extractive contents, and a higher total cellulose content, all of which contribute to high pulp yield and low consumption of chemicals in the pulping and bleaching treatments. It also has a high pentosan content, which contributes to the high bursting, folding and tensile strengths. Writing papers produced from waste paper mixed with 5% bleached abaca pulp from cold soda pulping or chemi-thermo-mechanical pulping, have a strength similar to that of waste paper blends with 20% softwood pulp.

Adulterations and substitutes The main substitutes for abaca for cordage are synthetic materials and sisal. Both are cheaper than abaca, but abaca is more slip-resistant than the other two, and stronger and more saltwater-resistant than sisal. Abaca's competitors for the production of specialty papers are synthetic fibres, such as viscose and polyester, which are also used blended with abaca. Other *Musa* species and sterile cultivars are occasionally used to make specialty papers, clothing, and fibre crafts, but none match the strength of *Musa textilis*.

Description Perennial, tufted herb, when mature and undisturbed consisting of 12–30 or more pseudostems in different stages of development; corm cylindrical, short, bearing buds developing short rhizomes with suckers, and numerous slender adventitious roots extending 2–3 m and mostly confined to the top 25 cm of the soil; pseudostem (formed by 12–25 leaf sheaths) cylindrical, 2.5–8 m tall, 15–20 cm in diameter at base, mostly green, sometimes irregularly streaked deep brown, red, purple or even almost black towards the base, bearing up to 12 leaves. Leaves spirally arranged, simple; petiole 30–70 cm long, stiff; blade narrowly oblong, 100–240 cm × 20–60 cm, rounded or cordate and unequal at base, rounded or acute at apex, generally uniformly deep-green above, glaucous beneath. Inflorescence a terminal, drooping, racemiform spike, arising from the rhizome, with the peduncle for its greatest part included in the pseudostem; axis with transversely arranged, 1–2-seriate groups (hands or combs) of 8–14 flowers, each group in the axil of a bract; bracts lanceolate, 10–50 cm × 6–12 cm, closely overlapping, deciduous, leathery, reddish brown to green. Flowers unisexual; perianth of 5 fused outer tepals and one adaxial inner tepal; male flowers in upper part of inflorescence, about 4 cm long, deciduous, with 5 slightly exserted stamens and one pistillode; female flowers in basal part of inflorescence (first 3–6 nodes), with inferior ovary 5 cm long.



Musa textilis – 1, habit; 2, bract with male flowers; 3, male flower; 4, fruit.
Source: PROSEA

Fruit bunch horizontal, lax; fruit a berry, narrowly ovoid or ellipsoid, 5–9 cm × 2–5 cm, curved at maturity, narrowed at base into a stout truncate stipe c. 1 cm long, pericarp 1 mm thick, ripening green; pulp scanty, pale buff, inedible; numerously seeded. Seeds subglobose-turbinate, very irregular in shape, c. 2–3 mm × 3–4 mm, smooth, black.

Other botanical information *Musa* comprises 30–50 species and numerous, mainly triploid hybrids. *Musa* is often divided into 5 sections, with *Musa textilis* belonging to section *Australimusa*. On the basis of AFLP analysis it has been proposed to reduce the genus to 3 sections, according to the number of chromosomes.

The general structure of *Musa textilis* is similar to that of the edible banana cultivars, but it is more slender, the leaves are smaller and the fruits are seeded. Only 20 of the more than 400 abaca cultivars in the Philippines are of commercial importance. Further taxonomic study of the species is needed.

Anatomy The fibre bundles are dispersed randomly in the outer and middle layers of the leaf sheath.

Growth and development Emergence of abaca from seed occurs 2–4 weeks after sowing. Growth is initially slow, but accelerates after 2–4 months. As the first pseudostem grows, numerous suckers also begin growth from the base of the plant. In the first pseudostems flowering is initiated 18–24 months after sowing. Plants raised from 1-year-old suckers may flower 10–12 months after planting, and those raised from corms after 16–18 months. Thereafter flowering in a clump occurs year-round. Abaca is allogamous and bat-pollinated. The stigmas are receptive for 2 days, and the pollen remains viable for 2 days. Self-pollination is impossible due to the separation of male and female flowers in the inflorescence and the earlier flowering of female flowers, but sib-pollination between pseudostems of the same clump is possible. The first mature fruits are present at 27–34 months after planting. Upon fruit ripening, the stem dies.

A cultivated plant usually consists of 10–20 pseudostems of varying maturity, with 4–8 of those stems flowering in any given year. Normally pseudostems are harvested just before flowering, so flowering and fruiting do not take place in a typical plantation. The plant will live up to 25 years, but is usually not cultivated for more than 15 years, because its productivity decreases from then onwards.

Ecology Abaca needs hot and humid conditions to grow well. It is successfully cultivated at latitudes between 5°S and 15°N, below 500(–1200) m altitude, and grows best with an evenly distributed annual rainfall of 2000–3200 mm, an average temperature of 27°C, and a relative humidity of about 80%. It does not tolerate drought, waterlogging or strong winds. Both extreme cold and extreme heat cause detriment to the plant. Abaca is best planted on deep, well-drained, fertile soil. This natural fertility is especially important considering that the crop is usually planted and harvested over many years with little or no fertilization.

Propagation and planting *Musa textilis* can be propagated with suckers, corms, seed, or in-vitro grown plants. Planting from seed is not common because plants take longer to reach maturity, and plants from seed do not express all traits of the parent plant due to high heterozygosity. Planting from seed is useful for breeding purposes, however. Suckers and corms are the most common planting materials. Corms are usually preferred over suckers since they are easier to handle and transport. In the preparation of corms, care should be taken not to destroy the bud eyes. Mature suckers are used to fill vacant spaces in established plantings. Corms and suckers can be obtained from existing planted fields or from a specifically-designated nursery with the plants in double rows 2 m apart, with 1 m between the paired rows and 1 m between plants within the row. In-vitro grown plants are also used for planting, especially in disease-control and yield improvement efforts.

Abaca can be planted irregularly among felled trees or in partially-cleared forest, or in a more orderly plantation. Planting materials are spaced at 2–3 m × 2–3 m, depending on cultivar size, resulting in a plant density of 1100–2500 plants/ha. They are planted in holes 40–50 cm deep, at the start of the rainy season (or year-round in areas without pronounced dry periods) to ensure a vigorous start.

Abaca can be intercropped with agroforestry trees such as *Leucaena leucocephala* (Lamk) de Wit to provide the abaca with shade and wind protection, and to maintain a constant temperature and humidity. Use of fruit trees or coconut (*Cocos nucifera* L.) for this function provides supplementary income in addition to protection of the abaca crop. During establishment of the plantation abaca can also be intercropped with annual food crops such as groundnut (*Arachis hypogaea* L.), cowpea

(*Vigna unguiculata* (L.) Walp.) or rice (*Oryza sativa* L.), and once the plantation has reached maturity it can be intercropped with shade-tolerant annual crops. Research in the Philippines has shown that cover cropping with leguminous plants such as *Calopogonium mucunoides* Desv. and *Desmodium heterocarpon* (L.) DC. subsp. *ovalifolium* (Prain) Ohashi can increase abaca yield.

Management Abaca requires little care compared to other crops. The field should be maintained free of weeds during the first year, through shallow cultivation and ring weeding at 2–3-month intervals. It has been estimated that 100 t/ha of fresh pseudostems and leaves of abaca remove 280 kg N, 13 kg P, 430 kg K and 89 kg Ca per ha. When the fibre is extracted in the field and all other plant parts are returned to the soil, the nutrient loss is considerably lower and chemical fertilizers are normally not applied. Canals can help drainage in moisture-retaining soils. Thinning of excess suckers may be performed so as to limit the number of pseudostems maturing yearly to 8. The duration of profitable production varies according to cultivar and growing conditions, and in properly maintained areas production may not decline for over 20 years. In general, however, replanting is undertaken when plants are 10–15 years old.

Diseases and pests Because abaca is a perennial and is usually vegetatively propagated, virus infections are a major concern. The most important viral diseases are abaca bunchy top virus (ABTV) and abaca mosaic virus (AbaMV). Abaca bunchy top virus, a babuvirus, is the most destructive disease of *Musa textilis*. It is transmitted by the banana aphid (*Pentalonia nigronervosa*). The virus can spread over long distances, as the wind can widely disperse winged forms of the aphid, and the virus is persistently retained by the aphid for 5–12 days. Infected plants develop chlorotic yellowish-white streaks and transparent veins; the plants become stunted and the crown of the plant develops a bunchy rosette growth form; finally the leaf blades dry up and turn brown. Recommended control is through a holistic approach of spraying to control the aphid vector, followed by removal of infected plants and herbicide treatment of the stumps to prevent sucker growth. Tissue culture of virus-free planting materials is important for replanting affected areas. Abaca mosaic virus, which has not yet been detected in Africa, is a strain of sugarcane mosaic virus (SCMV), a potyvirus. It is transmitted by various aphid species such as *Aphis gossypii*, *Aphid glycines* and *Rhopalosiphum maidis*, but this transmission is non-persistent (the virus lasts in the insect for less than four hours). The onset of abaca mosaic is characterized by mottling of the leaves, consisting of dark to pale green or yellowish streaks, which extend from the midribs to the margins; mottling also occurs on other parts of the plant. Affected plants do not grow to full size. Alternate hosts of the disease include sugarcane (*Saccharum officinarum* L.), maize (*Zea mays* L.), *Canna indica* L. and *Maranta arundinacea* L. Control measures include herbicide treatment, removal of infected plants and breeding for resistance.

The most important fungal disease of abaca is Fusarium wilt or Panama disease, caused by *Fusarium oxysporum* f.sp. *cubense*, which is also a major disease of the edible banana. It starts with rotting at the base of the pseudostem, with the rot moving upward until it reaches the leaf blades; plants become yellowish and eventually wilt. Cross sections of infected pseudostems and corms show black-purple vascular bundles. The first noticeable symptoms of the disease are the inward curling of the leaf blades at or near the tip of the lower leaves and the slow growth of the plants. The disease is spread primarily through planting material and tools and remains in the soil of infected fields. Hence the main control measures are use of clean planting material, removal and burning of infected plants, and quarantine of infected fields. Some cultivars demonstrate tolerance of the disease. Minor fungal diseases are dry sheath rot caused by *Marasmius* spp. and a stem rot caused by *Deightoniella torulosa* (synonym: *Helminthosporium torulosum*).

The corm weevil (*Cosmopolites sordidus*) is a major insect pest. It damages the plant by boring tunnels into the corm at the plant base. It can be controlled with insecticide treatment of planting material and the plant base, but as this is costly and environmentally hazardous, cultural control methods are preferred. These include the use of clean planting material, as the main spread of the weevil is through infested planting material.

Harvesting Pseudostems are harvested individually at the appearance of the flagleaf, a small leaf that precedes emergence of the inflorescence. Harvest of a pseudostem consists of topping the stem at the base of the leaf blades and felling the stem with a slanting cut near ground level. Usually 2–4 pseudostems are ready for harvesting at the same time. The first harvest can take place 18–24 months after planting, and subsequent harvests every 3–12 months, depending on growing conditions and cultivar. The yields from the first harvests are usually small and the best yields are obtained from plants that are 4–8 years old. The same plant may be harvested for 10–15 years without replanting.

Yield In 2001–2005 the estimated average fibre yield decreased from 1470 kg/ha to 1300 kg/ha in Ecuador, and from 680 kg/ha to 570 kg/ha in the Philippines. In Equatorial Guinea the estimated average yield in this period was about 280 kg/ha. Yields vary according to cultivar and location, and disease pressure is an important factor explaining the low yields in the Philippines.

Handling after harvest Within 24 hours after harvest, the usable leaf sheaths of the pseudostem are peeled away one by one. The leaf sheaths are normally grouped according to their position in the pseudostem, so as to separate fibres of different grades. The outermost sheaths give stronger, coarser, darker fibre (better for cordage), and the innermost sheaths give a lighter-coloured, weaker, finer fibre (better for paper-making).

In a process called 'tuxying', the outer layers of the leaf-sheaths are pulled off in ribbons 5–8 cm wide, with a knife or a sharp piece of bamboo. These ribbons or 'tuxies' are then 'stripped': they are cleaned of their pulp (epidermis and parenchyma) to yield clean fibres. This is accomplished either manually, by placing the tuxies between a flat wooden surface and a serrated knife and pulling the tuxies, or with an engine-driven spindle that pulls the tuxies between the knife and the flat surface. The finer the serrations of the knife, the cleaner and purer the resulting fibre, but the lower the fibre recovery (with non-serrated knifes giving the cleanest fibre, though in lesser quantity). Any pulp not removed from the fibre in this process will discolour the fibre during drying. Fibres can also be extracted by mechanical decortication, in which the entire pseudostem is crushed and cleaned of its pulp, though this yields a lower grade fibre because both the primary and the secondary fibres of the leaf sheaths are extracted at the same time and mixed together. Hand stripping normally gives a fibre recovery of 1.2–1.5% of the fresh pseudostem weight, spindle stripping 1.5–2.5%, and machine decortication 3–4%. In the Philippines most farmers use hand stripping, whereas in Ecuador almost all abaca fibre is extracted with spindle stripping. The extracted fibre is hung on poles to dry, under a roof or in the open (or mechanically, in the case of machine decortication). After a drying period of a few hours to a few days, the fibre is graded and put in bales of 125 kg. The standard grades in the Philippines are divided into 2 main classes: hand-stripped and spindle-stripped. Within each class the fibre is further graded according to strength, cleaning, colour, texture and length. The grading system in Ecuador is simpler, and is mainly based on the colour and diameter of the fibre strands.

The paper industry uses the best abaca fibre grades for strong, porous papers such as tea bags and sausage casings. Lesser grades are used to make strong papers such as vacuum cleaner bags and Manila envelopes. Pulping is usually accomplished through the soda, alkaline sulphite and kraft processes, though cold soda pulping (CSP) and chemo-thermo-mechanical pulping (CMTP) also produce paper with good strength and optical properties. Pulps suitable for the production of rayon viscose have been prepared from abaca fibre using the kraft and alkaline sulphite pulping processes. It is possible to biologically bleach abaca kraft pulp using the white rot fungus *Trametes versicolor*.

Genetic resources The Philippines is the centre of genetic diversity of the species. The National Abaca Research Center (NARC), based at Leyte State University in Leyte, Philippines, holds the world's largest collection of *Musa textilis* germplasm, with more than 600 accessions of both cultivated and wild types. Accessions are also conserved in vitro. Part of the collection at NARC has been characterized with respect to fibre morphology, chemical composition, fibre quality and physical properties. Though *Musa textilis* is a genetic contributor in certain edible seedless hybrid banana varieties, it has not been used in any breeding programs for edible bananas.

Breeding Most genetic improvement work is carried out in the Philippines. Priorities in breeding are disease and pest resistance, especially to viruses. Other priorities include early maturity, high yield and fibre quality, and drought and acid tolerance. Genetic engineering has been proposed to insert genes for resistance to different viruses into *Musa textilis* from wild, seedless relatives. Wild relatives for possible improvement through traditional breeding or biotechnology include 'pacol' (a strong-fibred form of *Musa balbisiana* Colla), 'canton' and 'minay' (sterile hybrids of *Musa textilis* and *Musa balbisiana*), and *Musa alinsanaya* R.V.Valmayor.

Prospects Successful cultivation of *Musa textilis* has long been confined to the Philippines and, more recently, Ecuador. In the Philippines numerous efforts are underway to increase abaca production through disease control, opening of new areas to plantations, mechanization of fibre extraction, and replanting of typhoon-damaged fields to new, disease-tolerant varieties. These efforts may also favour abaca production in other regions as well. Information on production and yields in Africa is hard to find, but it would seem that yields are very low in Equatorial Guinea, the main African producer of abaca. Still, abaca could be an interesting crop for both small and large producers in tropical Africa. It requires little maintenance and few inputs, and is compatible with intercropping of food, forage and tree species. Despite competition from sisal and synthetic fibres, abaca fibre is increasingly demanded on the world market, and this should continue as new uses are discovered. In a world increasingly concerned about the environment, abaca offers a number of environmental advantages over synthetic cordage and over fibreglass for plastic composites. Its production is carbon-neutral or even negative, and the by-products from its production and processing are readily biodegradable. Abaca is more environmentally desirable even than many other natural fibres, as it is grown with few petroleum-derived inputs such as synthetic fertilizers, and the extraction of abaca fibre uses little or no chemicals or water.

Major references Bajet & Magnaye, 2002; Constantine, 1999–2008; Franck (Editor), 2005; Gambley et al., 2004; Gonzal & Valida, 2003; Jarman, 1998; Mwaikambo, 2006; Raymundo & Bajet, 2000; Sharman et al., 2008; Wu & Kress, 2000.

Other references Aguiba, 2005; Armecin et al., 2005; Backer & Bakhuizen van den Brink Jr, 1968; Biagiotti, Puglia & Kenny, 2004; Cooper, Spillane & Hodgkin, 2001; FAO, 2007; FAO, 2009; FAO, 2010; Göltenboth & Müller, 2010; Guarte, 2006; Häkkinen & Väre, 2008; Ikitoo, 1997; Ilvessalo-Pfäffli, 1995; Lockhart, 2000; Roecklein & Leung (Editors), 1987; Rutherford & Kangire, 1999; Seshu Reddy, Gold & Ngode, 1999; Thomas, 2000; Tushemereirwe & Bagabe, 1999; Wong et al., 2002.

Sources of illustration Gonzal & Valida, 2003.

Authors G. Vaughan

Based on PROSEA 17: Fibre plants.

NEOAPALOXYLON TUBEROSUM (R.Vig.) Rauschert

Protologue Taxon 31: 559 (1982).

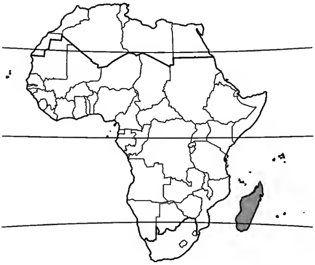
Family Papilionaceae (Leguminosae - Papilionoideae, Fabaceae)

Synonyms *Apaloxylon tuberosum* R.Vig. (1949).

Origin and geographic distribution *Neoapaloxylon tuberosum* is an endemic species of western and southern Madagascar.

Uses The fibrous bark is used for rope. In the past the bark was used for making barkcloth. The tuberous root is eaten. The wood is soft and white and is only used as fuelwood.

Botany Deciduous shrub or small tree up to 13 m tall; bole up to 40 cm in diameter; bark surface smooth and pale grey, with numerous lenticels; twigs glabrous, dark grey, with pale lenticels. Leaves alternate, pinnately compound with 10–16 leaflets; stipules minute; petiole and rachis flattened, 4–11 cm long; petiolules 1–1.5 mm long; leaflets alternate, oblong-obovate, (9–)15–30(–50) mm × 7–15(–20) mm, unequal, glabrous, pinnately veined. Inflorescence a panicle, often many together in dense and complex clusters, branches up to 4 cm long, many-flowered. Flowers bisexual, regular, greenish white, sessile; hypanthium obconical, 0.5 mm long, resembling a pedicel; sepals 4, free, broadly elliptical, 3–3.5 mm long, concave, with obscure gland dots; petals absent; stamens 10, free, 5–8 mm long; disk



Neoapaloxylon tuberosum – wild

prominent, yellow-green; ovary superior, c. 1 mm long, with stipe c. 1 mm long, glabrous, style slender, c. 5 mm long. Fruit an indehiscent pod 4.5–6 cm long, with 3–5 mm long stipe, glabrous, pale brown, with a single apical seed and a large basal wing, with persistent sepals at base. Seed oblong-ovate, flat, 13–15 mm long, reticulately veined, blackish brown.

Neoapaloxylon tuberosum flowers when it is leafless and is then very conspicuous because of the profusion of flowers. Flowers appear at the start of the dry winter and fruits mature before the leaves appear. The fruits, which strongly resemble those of maples (*Acer*) except that the seed is at the apex and the wing at the base, are dispersed by wind. The wing causes the fruit to spin rapidly and fall slowly.

The genus *Neoapaloxylon* comprises 3 species and the bark of all 3 is used for rope. *Neoapaloxylon madagascariense* (Drake) Rauschert is a tree up to 15 m tall. *Neoapaloxylon mandrarense* Du Puy & Rabev. is a shrub or small tree 3–5 m tall. The root is eaten. The genus *Neoapaloxylon* is very close to another Madagascan endemic genus *Brandzeia*, which has a single species, *Brandzeia filicifolia* Baill., a tree of up to 25 m tall that is used for timber.

Ecology *Neoapaloxylon tuberosum* occurs from sea-level up to 900 m altitude in arid to sub-arid, deciduous forest in western and southern Madagascar. It apparently has a preference for limestone soils.

Genetic resources and breeding As *Neoapaloxylon tuberosum* is fairly widespread in Madagascar and apparently not heavily exploited, no major threats of genetic erosion are envisaged.

Prospects *Neoapaloxylon tuberosum* is poorly known and only locally used. It may have potential for ornamental use.

Major references du Puy et al., 2002; Rauschert, 1982; Schatz, 2001; Stiles, 1998.

Other references Boiteau, Boiteau & Allorge-Boiteau, 1999; Fougère-Danezan et al., 2010; ILDIS, 2005; Lewis et al., 2005.

Authors C.H. Bosch

NEUROPELTIS ACUMINATA (P.Beauv.) Benth.

Protologue Hook., Niger Fl.: 469 (1849).

Family Convolvulaceae

Chromosome number $2n = 28$

Origin and geographic distribution *Neuropeltis acuminata* is distributed from Senegal to the Central African Republic, DR Congo and Angola.

Uses In Ghana and Côte d'Ivoire the stems of *Neuropeltis acuminata* are used as ropes and for tying in the construction of houses. In Gabon the leaves are eaten as a vegetable.

Botany Woody liana with contorted stems up to 40 m long and with diameter up to 25 cm. Leaves alternate, simple; petiole 8–25 mm long; blade elliptical, 5–12 cm × 5–6 cm, rounded to cuneate at base, apex acuminate, margin entire. Inflorescences axillary and terminal racemes, up to 50-flowered, 12–30 cm long. Flowers bisexual, regular, 5-merous, fragrant; pedicel up to 4 mm long, bract strongly accrescent after flowering; sepals circular to elliptical, 1.5–3 mm long, pubescent; corolla campanulate, 5–9 mm long, with short tube, white with greenish tinge, sparsely pubescent on outside of lobes; stamens inserted at base of corolla tube, filaments glabrous, whitish; ovary superior, 2-celled, style filiform, c. 2.5 mm long, stigmas 2. Fruit a rounded capsule 7 mm in diameter, surrounded at base by persistent calyx and enlarged bract. Seeds 1(–2), globose, black, glabrous.

In Ghana flowering is in December–January.

Neuropeltis comprises about 13 species, of which about 9 in tropical Africa and 4 in tropical Asia. *Neuropeltis occidentalis* Breteler is restricted to an area from Guinea eastward to Côte d'Ivoire. In Sierra Leone its stems are used as a source of rope of high quality. *Neuropeltis prevosteoides* Mangenot is restricted to Liberia and Côte d'Ivoire, where its stems are used for tying in house construction. *Neuropeltis velutina* Hallier f. occurs in Nigeria and Central Africa but the name has been misapplied to *Neuropeltis occidentalis*.

Ecology *Neuropeltis acuminata* occurs in evergreen primary forest as well as in secondary and gallery forests, and in swamps. In older forest it becomes one of the dominant climbing species. It has been recorded from altitudes up to 1500 m.

Genetic resources and breeding *Neuropeltis acuminata* seems not threatened with genetic erosion.

Prospects *Neuropeltis acuminata* is only locally used as a source of tying material, and its importance is unlikely to increase.

Major references Breteler, 2010; Burkill, 1985; Lejoly & Lisowski, 1984; Tra Bi, Kouamé & Traoré, 2005.

Other references Irvine, 1961; Kuzee & Bongers, 2005; Leistner, 2005; Mangenot & Mangenot, 1957; Missouri Botanical Garden, undated; Shaw, 1945; Staples, 2006.

Authors C.H. Bosch

OBETIA RADULA (Baker) B.D.Jacks.

Protologue Index Kew. 3: 323 (1895).

Family Urticaceae

Synonyms *Obetia pinnatifida* Baker (1883).

Vernacular names Stinging nettle tree (En).

Origin and geographic distribution *Obetia tenax* is distributed in eastern DR Congo, Rwanda, Burundi, Kenya, Uganda, Tanzania, Comoros, Mayotte and Madagascar.

Uses The stem yields a fibre of good quality used in basketry and for making strong cordage and textiles. It can be made into high-quality paper, e.g. for banknotes. In Madagascar the fibre was formerly used to ignite fire.

In traditional medicine in Kenya a root infusion is given to treat infertility in women. In Uganda the boiled root is chewed against premature ejaculation, and the root and leaf are used in the treatment of cough. In DR Congo the leaf is crushed and the juice instilled in the nostrils for the treatment of madness. In Kenya the leaf juice or a leaf extract is used as mouthwash for treatment of toothache. In Madagascar a decoction of unspecified plant parts is given as an antispasmodic in case of whooping cough and asthma. The leaf is used in East Africa to deter rats and moles. In Kenya and Madagascar the plant is considered to have magic properties.

Properties The fibre is beautiful, and much appreciated in Madagascar. The wood is soft with much sap in it. Contact with the stinging hairs on the leaf causes intense itching. Both fresh and dried stinging hairs have stimulating effects on isolated guinea pig ileum. Compounds isolated from the stinging hairs and possibly contributing to the stinging effect include histamine, serotonin and acetylcholine.

Botany Deciduous shrub or small tree up to 13 m tall, sparsely branched, presumably dioecious; bole up to 50 cm in diameter; outer bark grey or brown, smooth to flaky, with very noticeable leaf scars; branchlets covered with large stipules and stinging hairs. Leaves alternate, clustered at the end of branches, simple; stipules free, lateral, ovate to almost round, 1–2.5 cm × 1–2 cm, apex acute to acuminate, glabrous or ciliate, green, persistent; petiole 8–16 cm long, pubescent, with many stinging hairs up to 2.5 mm long; blade ovate, lobed or divided, rarely entire, 6–25(–36) cm × (5–)15–25(–30) cm, base deeply cordate, lobes triangular and unlobed to lobed, acuminate at the apex, margin toothed, upper surface with short hairs and scattered stinging hairs, lower surface densely hairy and with scattered stinging hairs on the veins, mineral concretions visible from above in the form of dots, lateral veins in 5–7 pairs. Inflorescence an axillary panicle up to 30 cm long, much branched, with flowers in small clusters at the branching points or scattered along the axes, pubescent and with many stinging hairs, rarely persisting after leaves have fallen, peduncle c. 5 cm long, male inflorescence much smaller than the female. Flowers unisexual, yellow-green; male flowers regular, 5-merous, almost sessile, perianth globular and up to 2 mm in diameter, rudimentary ovary present; female flowers 4-merous, almost sessile, yellow, perianth up to 1 mm in diameter, outer pair of tepals smaller than inner pair, both pairs becoming thinly membranous, ovary superior, ovoid, staminodes absent. Fruit an achene 1–1.5 mm long, compressed, enclosed in the persistent membranous perianth.

In Kenya *Obetia radula* flowers in February–April and September–December.

Obetia comprises 8 species, distributed in eastern Central Africa, East Africa, southern Africa and the Indian Ocean islands, mostly in dry habitats. The bark of *Obetia madagascariensis* (Poir.) Wedd., a shrub or small tree endemic to western and southern Madagascar, also yields an excellent fibre. It was formerly used for making fishing lines, but has been replaced by nylon fibre. The leaf is used for treatment of eye diseases.

Ecology *Obetia radula* occurs from sea level up to 2000 m altitude, on rocky slopes in evergreen or semi-evergreen bushland, sometimes on rocky shores of lakes and rivers and at the margin of dry montane forest.

Management In Madagascar *Obetia radula* is planted around houses and conserved when land is cleared; it can thus be found in villages and in hedges around fields.

Genetic resources and breeding In view of its fairly wide distribution, *Obetia radula* does not seem in danger of genetic erosion.

Prospects *Obetia radula* is a useful local source of fibre and traditional medicines. Detailed information on the fibre and pharmacological properties is lacking, however, making it difficult to assess the prospects for this species. The presence of stinging hairs makes handling of the plant difficult.

Major references Beentje, 1994b; Boiteau, Boiteau & Allorge-Boiteau, 1999; Friis, 1983; Friis, 1989c; Leandri, 1965.

Other references Chifundera, 2001; Debray, Jacquemin & Razafindrambao, 1971; Hauman, 1948b; Heine & Heine, 1988b; Icikawa, 1987; Maitai et al., 1981; Neuwinger, 2000; Rolland & Boullet, 2005; Tabuti, Lye & Dhillion, 2003; Watt & Breyer-Brandwijk, 1962.

Authors M. Brink

OBETIA TENAX (N.E.Br.) Friis

Protologue Kew Bull. 38: 226 (1983).

Family Urticaceae

Synonyms *Urera tenax* N.E.Br. (1888).

Vernacular names Tree nettle, mountain nettle, rock tree nettle (En).

Origin and geographic distribution *Obetia tenax* is distributed in Botswana, Zimbabwe, Mozambique, South Africa and Swaziland.

Uses The bark yields a fibre which is made into tough cords, ropes, nets and mats. The bark is used for thatching. The leaf is cooked as a green vegetable (often mixed with that of *Pouzolzia mixta* Solms) and eaten with porridge. Root pulp is applied on snakebites.

Properties The bark fibre is strong. The wood is soft and fibrous, with a spongy pith or hollow centre. Contact with the stinging hairs causes intense itching and burning, and may result in blisters on the skin.

Botany Deciduous shrub or small tree up to 5(–7) m tall, presumably dioecious; outer bark purplish brown to grey, often longitudinally striate, large leaf scars present; younger branches densely covered with stinging hairs. Leaves alternate, simple; stipules free, lateral, lanceolate, 4–8 mm × 1–2.5 mm, apex long-acuminate, glabrous; petiole up to 14 cm long, with stinging hairs; blade ovate to almost circular, sometimes slightly 3-lobed, 3.5–15(–17) cm × 3–11.5(–19) cm, base broadly cordate, truncate or rounded, apex rounded, acute or broadly acuminate, margin coarsely toothed, upper surface with stinging hairs and a few stiff hairs, lower surface with scattered stiff hairs and stinging hairs along the veins. Inflorescence an axillary, much branched panicle, up to 10 cm long, with numerous stinging hairs. Flowers unisexual, very small, whitish to yellowish green; male flowers in dense inflorescences, regular, 5-merous, pedicellate, 1–2 mm in diameter, tepals usually with stinging hairs, rudimentary ovary present; female flowers solitary or in small clusters along axes and branches of inflorescence, 4-merous, shortly pedicellate, c. 1 mm long, outer pair of tepals smaller than inner pair, both pairs becoming thinly membranous, glabrous, ovary superior, ovoid, staminodes absent. Fruit an achene c. 1.5 mm long, compressed, ochre to brown, enclosed by the persistent membranous perianth.

Obetia tenax flowers in August–September and fruits in October–November.

Obetia comprises 8 species, distributed in eastern Central Africa, East Africa, southern Africa and the Indian Ocean islands, mostly in dry habitats.

Ecology *Obetia tenax* occurs from sea level up to 1800 m altitude, in deciduous bushland in rocky locations.

Genetic resources and breeding It is unknown whether *Obetia tenax* is threatened by genetic erosion.

Prospects *Obetia tenax* is a useful local source of fibre for cordage. Detailed information on the fibre properties is lacking, however, making it difficult to assess the prospects for this species. The presence of stinging hairs makes handling of the plant difficult.

Major references Coates Palgrave, 1983; Friis, 1991; Friis & Immelman, 2001; van Wyk & van Wyk, 1997.

Other references Cavendish, 1999; CJB & SANBI, 2006; Friis, 1983; Hyde & Wursten, 2009b; Loffler & Loffler, 2005; Neuwinger, 2000; Shackleton et al., 1998; Watt & Breyer-Brandwijk, 1962.

Authors M. Brink

ONCOCALAMUS WRIGHTIANUS Hutch. & H.Wendl.

Protologue Fl. W. trop. Afr. 2: 391 (1936)

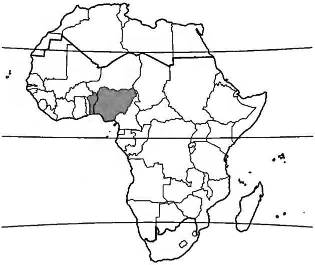
Family Arecaceae (Palmae)

Origin and geographic distribution *Oncocalamus wrightianus* is distributed in southern Benin and southern Nigeria.

Uses In Nigeria the split stem is used for making coarse cordage, fine twine, string and thread. In Benin the stem is recorded to be used for making baskets. The base of the leaf sheath is used as a chew stick.

Properties The stems of *Oncocalamus* species are weak and brittle, and therefore not valued for the production of cane furniture.

Botany Clustering, fine, slender rattan



Oncocalamus wrightianus – wild

palm, climbing up to 10 m high; stem up to 10 m long, 6–10 mm in diameter without sheaths, 8–15 mm with sheaths, internodes c. 15 cm long. Leaves pinnately compound, juvenile leaves bifid; sheath tubular, striate, white-hairy, moderately to sparsely armed with caducous black spines, often shed and leaving raised, triangular, blister-like scars; knee absent; ocrea horizontally truncate, extending up to 3 cm beyond leaf, armed like sheath; petiole absent or less than 2 cm long; rachis up to 60 cm long, unarmed, distally prolonged into a 35–45 cm long cirrus bearing acanthophylls (leaflets modified into reflexed hooks) up to 18 mm long; leaflets 5–15 on each side of the rachis, composed of 2–4 folds, broadly lanceolate or sigmoid, 10–15 cm × 2–5 cm, apex acute, margin sparsely armed with fine spines, papery. Flowers unknown. Fruit unknown.

Oncocalamus comprises 4 or 5 species and is distributed from southern Benin to northern Angola. Until recently it was considered to consist of a single species, *Oncocalamus mannii* (H.Wendl.) H.Wendl. *Oncocalamus mannii* sensu stricto is a slender to moderately sized rattan with stems up to 30 m long and 8–16 mm in diameter (12–28 mm with sheaths). It is distributed in southern Cameroon, Equatorial Guinea and Gabon. In the absence of other rattans the stem is used in coarse basketry, but it is rather inflexible and prone to breaking. *Oncocalamus tuleyi* Sunderl. is a robust rattan with stems up to 30(–50) m long and 13–22 mm in diameter (25–45 mm with sheaths). It occurs in south-eastern Nigeria and western Cameroon. In Nigeria the epidermis of the stem is used for tying yams to poles. In Cameroon the base of the leaf sheath is used as a chew-stick. *Oncocalamus tuleyi* is considered vulnerable.

Ecology *Oncocalamus wrightianus* occurs in swamp forest, savanna forest margins and secondary forest.

Genetic resources and breeding *Oncocalamus wrightianus* is considered an endangered species, but is not yet included as such in the IUCN Red list of threatened species.

Prospects Because of the weak and brittle stems, *Oncocalamus wrightianus* and other *Oncocalamus* species are much less valued than other African rattans (*Calamus*, *Eremospatha* and *Laccosperma* species). The stems are not suitable for furniture and construction, and they are only occasionally used for basketry and cordage.

Major references Akoègninou, van der Burg & van der Maesen, 2006; Sunderland, 2001b; Sunderland, 2007.

Other references Hutchinson, 1963; Sunderland, 2001a; Sunderland, 2002b.

Authors M. Brink

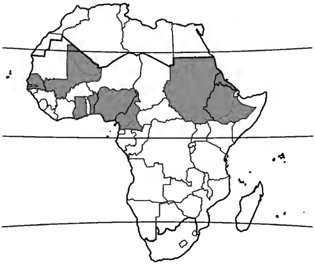
ORMOCARPUM PUBESCENS (Hochst.) Cufod. ex Gillett

Protologue Kew Bull. 20(2): 348 (1966).

Family Papilionaceae (Leguminosae - Papilionoideae, Fabaceae)

Synonyms *Ormocarpum bibracteatum* (Hochst. ex A.Rich.) Baker (1871).

Origin and geographic distribution *Ormocarpum pubescens* is distributed from Senegal eastwards to Eritrea and Ethiopia but has not yet been collected in a number of countries in



Ormocarpum pubescens – wild

between.

Uses The resilient stems of *Ormocarpum pubescens* are bent after they have been softened over a fire and made into circular bands for roof construction, into frames for fishing-nets and into traps. The species has considerable value as an ornamental. In Eritrea the branches are burnt to provide a smoke bath that is used, most often by women, for smoothening the skin and to give it an attractive tint.

Properties The branches are not only soft and flexible but also very strong and therefore especially valued by hunters for making traps for big game. The bruised leaves smell like gooseberries (*Ribes uva-crispa* L.).

Botany Small tree up to 8 m tall, with narrow crown, grey pubescent all over; bole up to 12 cm in diameter, usually divided low down into vertical stems with few lateral branches. Leaves alternate on young stems, in whorls of 2–4 on old branches, imparipinnately compound with (10–)13–17(–25) leaflets; stipules ovate to triangular, 4–7 mm long; rachis up to 7 cm long; leaflets opposite, sub-opposite or alternate, elliptical-oblong, 6–10 mm × 4 mm, with a small mucro at apex, glabrous above, slightly white soft-hairy below. Flowers few in short racemes clustered at the ends of short shoots, bisexual, papilionaceous; pedicel up to 1.5 cm long with a pair of ovate bracteoles near the apex; calyx 8–10 mm long; corolla c. 2 cm long, reddish with purple veins and mottles; stamens 10, fused into 2 groups of 5; ovary superior, curved, 1-celled, style slender, c. 10 mm long. Fruit a flat pod 2–3.5 cm long, usually coiled but sometimes straight, pubescent, minutely tuberculate, black when ripe, indehiscent, (2–)4–5(–6)-segmented.

Ormocarpum pubescens probably grows slowly, with growth restricted to the slow extension of the short shoots which produce flowers and leaves at their tips. Flowering is during the first half of the dry season when the plant is leafless.

The genus *Ormocarpum* comprises c. 18 species of which 17 occur in tropical Africa. It is related to *Ormocarpopsis*, a genus endemic to Madagascar, which does not have segmented pods. In the literature there is considerable confusion concerning *Ormocarpum pubescens* and *Ormocarpum kirkii* S.Moore. The latter is distributed from southern Somalia southwards to Transvaal in South Africa. *Ormocarpum verrucosum* P.Beauv. is a shrub up to 4 m tall, distributed from Senegal to Angola near beaches on sandy soils and in brackish swamps. Its stems are used in the same way as those of *Ormocarpum pubescens*.

Ecology *Ormocarpum pubescens* occurs up to 2100 m altitude in woodland in the Sudanian climate zone, usually on rocky outcrops, coarse grained soils and shallow soils.

Genetic resources and breeding Although *Ormocarpum pubescens* has a wide distribution, it is uncommon and individual plants are often far apart. As the species is apparently not heavily exploited, the risk of genetic erosion seems low.

Prospects The use of *Ormocarpum pubescens* will remain important only locally. The species has considerable potential as an ornamental plant.

Major references Arbonnier, 2000; Burkill, 1995; Keay, Onochie & Stanfield, 1964.

Other references Akoègninou, van der Burg & van der Maesen, 2006; Aubréville, 1950; Ghebru & Mehari (Editors), 2007; Gillett, 1966; Hauman et al., 1954; Hepper, 1958; Thulin, 1989.

Authors C.H. Bosch

PACHYCARPUS SPURIUS (N.E.Br.) Bullock

Protologue Kew Bull. 1953: 338 (1953).

Family Asclepiadaceae (APG: Apocynaceae)

Synonyms *Xysmalobium spurium* N.E.Br. (1895), *Xysmalobium dolichoglossum* K.Schum. (1900), *Schizoglossum dolichoglossum* (K.Schum.) N.E.Br. (1902), *Schizoglossum spurium* (N.E.Br.) N.E.Br. (1902).

Origin and geographic distribution *Pachycarpus spurius* occurs in south-eastern DR Congo, southern Tanzania and Malawi.

Uses The stem fibre is used for making twine and rope in Tanzania. The pounded leaves are mixed with water and drunk as a galactogogue, and the tuber is eaten by men to improve fertility.

Production and international trade The fibre obtained from *Pachycarpus spurius* is only used locally.

Botany Perennial herb with 1–5 annual stems 1–2 m long, arising from a long, cylindrical, vertical rootstock, sometimes with a few fusiform laterals; stems unbranched, erect, densely white hairy, containing white latex. Leaves opposite, simple and entire; petiole 3–10(–15) mm long, pubescent; blade lanceolate to broadly ovate, 6–13 cm × 3–8.5 cm, base rounded and slightly cordate, apex acute or obtuse, margin scabrid, both surfaces minutely pubescent, secondary veins numerous, parallel, prominent. Inflorescence a terminal or extra-axillary umbel, nodding or directed to one side, 4–9-flowered; peduncle 2–4.5 cm long, densely pubescent; bracts c. 10 mm long, filiform, pubescent. Flowers bisexual, 5-merous; pedicel 1.5–2.5(–3) cm long, densely pubescent; calyx lobes ovate to lanceolate, 6–11(–14) mm × 3–4(–7) mm, acute, pubescent; corolla globose-campanulate, glabrous or minutely papillate inside, pubescent outside, reddish purple or occasionally cream outside, white, cream or purple inside, often with darker veins; lobes oblong, ovate or obovate, (11–)14–22 mm × (6–) 8–14 mm, acute or obtuse, recurved at the tip; stamens 5, united into a stipitate staminal column and adnate to the ovary; corona lobes arising from the base of the stipe, spreading below, erect or slightly recurved above, 10–20 mm × 4–8 mm, spathulate, apex acute to truncate or emarginate, entire or variously toothed; anthers sessile, with wings 3–4 mm × 1–1.5 mm, triangular and convex; anther appendages 1–2 mm × 1.5 mm, broadly ovate, acute and inflexed over stigma head; ovary superior, by abortion reduced to 1 carpel, stigma head flat, 3–4 mm in diameter, forming a raised circular cushion c. 1 mm above top of anthers. Fruit c. 7 cm × 3–3.5 cm, ovoid and somewhat inflated, with 4 or 6 broad, longitudinal, apically toothed wings, pubescent.

Pachycarpus comprises 37 species in sub-Sahara Africa.

Ecology *Pachycarpus spurius* occurs at (1200–) 1500–2100 m altitude in grassland and *Brachystegia* or *Protea* scrubby woodland, sometimes in disturbed sites.

Management *Pachycarpus spurius* only occurs wild.

Genetic resources and breeding *Pachycarpus spurius* has a large area of distribution and is probably not in danger of genetic erosion.

Prospects Too little is known about *Pachycarpus spurius* to assess its prospects as a fibre plant.

Major references Bullock, 1953; Goyder, 1998; Kirby, 1963.

Other references Burrows & Willis, 2005; Watson & Dallwitz, 1992–.

Authors L.P.A. Oyen

PANDANUS ABBIWII Huynh

Protologue Bot. Helvet. 97(1): 81 (1987).

Family Pandanaceae

Vernacular names Screw pine (En).

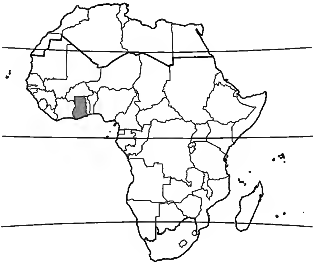
Origin and geographic distribution *Pandanus abbiwii* occurs in Ghana.

Uses The leaves of *Pandanus abbiwii* are used for making mats, baskets and fish traps, while the fibrous root is used for brushes. The fruit has a pleasant flavour. An infusion of the bark is taken for the treatment of diarrhoea and dysentery.

Botany Dioecious, small tree up to 12 m tall with aerial roots and a branched trunk. Leaves simple, without petiole but with broad clasping base, linear, up to 250 cm × 8 cm, tapering to the apex, margins and midvein with numerous sharp spines, with 94–100 longitudinal veins. Infructescence consisting of 3–5 syncarps; apical syncarp suboblong, c. 26 cm × 12.5 cm. Fruit a 4–9-angular drupe 4–4.5 cm × 1.5 cm × 1.5 cm, usually 2–3-locular, yellow when ripe, upper part of drupe free and dome-shaped.

Pandanus includes about 600 species and is found from West Africa eastward to Madagascar, the Indian Ocean islands, India and most of warmer South-East Asia and the Pacific islands. From Madagascar c. 80 *Pandanus* species have been reported, and from mainland Africa some 25 species.

Pandanus candelabrum P.Beauv. occurs in Nigeria, where the leaves have been used for making bags for holding salt. In traditional Nigerian medicine the leaves are used for the treatment of sore throat, and bark infusions are used to cure diarrhoea, dysentery and enteritis. Formerly, all *Pandanus* plants occur-



Pandanus abbiwii – wild

ring from Senegal eastwards to Angola were considered to belong to *Pandanus candelabrum*, but more recently a range of species with restricted endemicity have been identified, among which *Pandanus abbiwii*. As recorded uses of *Pandanus* in West and Central Africa have usually been attributed to *Pandanus candelabrum* and not to the new species, assessment of the uses and properties of most new species is difficult.

In Sierra Leone material for weaving mats is obtained by scraping the leaf of *Pandanus triangularis* H.St.John ex Huynh between a knife and the fingers and drying the product in the sun. Fibre obtained after retting the leaf in water is made into rope, which is sometimes used for making long baskets in which fish are put when caught.

Ecology *Pandanus abbiwii* occurs along rivers and near beaches.

Genetic resources and breeding In view of the limited distribution of *Pandanus abbiwii* the risk of genetic erosion may be high.

Prospects *Pandanus abbiwii* is a useful local source of material for weaving. Little is known about this species, however. The taxonomy of *Pandanus* in West and Central Africa needs further elucidation.

Major references Abbiw, 1990; Burkill, 1997; Huynh, 1987; Huynh, 1989; Irvine, 1961.

Other references Huynh, 1988; Huynh, 1991; Idu, Obaruyi & Erhabor, 2008; Laivao, 2008.

Authors M. Brink

PANDANUS ODORATISSIMUS L.f.

Protologue Suppl. pl.: 424 (1782).

Family Pandanaceae

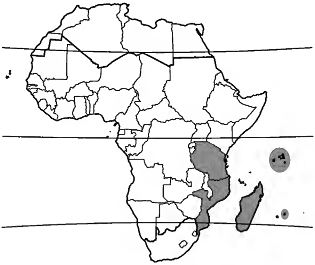
Chromosome number $2n = 60$

Synonyms *Pandanus fascicularis* Lam. (1785), *Pandanus sabotan* Blanco (1837), *Pandanus tectorius* auct. non Parkinson.

Vernacular names Pandan, pandanus, screw pine (En). Pandano (Po).

Origin and geographic distribution *Pandanus odoratissimus* is widely distributed on the Indo-Malaysian coasts from India and Sri Lanka throughout South-East Asia to Taiwan, the Ryukyu Islands and Micronesia. In has been introduced into tropical Africa where it is occasionally cultivated.

Uses On Pemba (Tanzania) *Pandanus odoratissimus* is cultivated to obtain thatching and weaving material, and for its fragrant male inflorescence. In Madagascar as well, the leaves are used for thatching and weaving. In Asia the leaves of *Pandanus odoratissimus* are made into hats, mats, sacks, cordage, baskets, umbrellas and other articles, and they also serve for thatching. On Guam they have been used to make sails. Beaten prop roots are used as brushes for painting and whitewashing, and the roots serve for binding. The leaves are said to be good paper-making material. On the Andaman and Nicobar Islands the leaves are used for wrapping cigars and the inflorescences as a substitute for tobacco.



Pandanus odoratissimus – planted

In India (mainly Orissa) and Sri Lanka the flavourings and perfumes 'kewda (keora) attar', 'kewda water' and 'kewda oil' ('rooh kewda') are prepared from the fragrant male inflorescence. The most important use of kewda attar is in tobacco preparations, but it also serves to flavour betel-quid, and to scent clothes, bouquets, lotions, cosmetics, soaps, hair oils and incense sticks. Kewda attar and kewda water are both used for flavouring food, sweets, syrups and soft drinks. Kewda oil is not produced in large quantities. In Indonesia the male inflorescence is used to scent clothes, in the preparation of fragrant oils and in ceremonies.

The seeds are edible and the fruit pulp is also consumed after the calcium oxalate has been removed by cooking. *Pandanus odoratissimus* is used in living fences, coastal windbreaks, and it is planted for soil stabilization and as an ornamental.

In Asia the roots are used for the treatment of skin diseases, ulcers, dyspepsia, diabetes, fever and leprosy, and they are also considered antipyretic, expectorant and diuretic. The leaves are used as a cardiotonic and purgative, and are said to be useful against leprosy, smallpox, scabies and heart and brain diseases. The male inflorescence is considered cardiotonic. Kewda oil and attar are considered stimulant and antispasmodic, and are used for the treatment of headache and rheumatism.

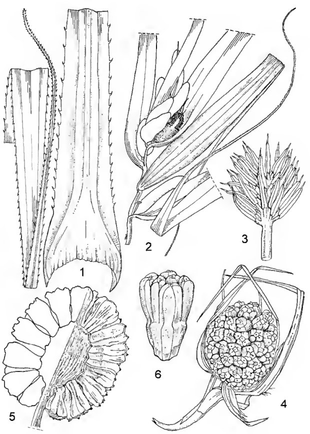
Production and international trade On a monetary basis, the most important *Pandanus* products are kewda attar and kewda water. The demand has increased strongly since the early 1980s, due to the popularity of scented tobacco products. It is estimated that about 35 million inflorescences (about 3500 t), obtained from about 5000 ha of wild *Pandanus odoratissimus* in Orissa (India), are processed annually to produce kewda attar and kewda water. Kewda oil is not produced on a commercial scale.

Properties The suitability of *Pandanus* leaves for weaving is due to their anatomy: the veins run parallel along the length of the leaves, whereas the transverse, connecting veins are relatively weak. The strips get their strength mainly from the upper epidermis and the hypodermis below it.

The characteristic aroma of kewda oil is due to 2-phenylethyl methyl ether, the main constituent (66–85%). Another major constituent is terpinen-4-ol (9–21%). The oil is considered to have stimulant and antispasmodic properties.

Root extracts have shown in-vitro antioxidant activity, with methanolic extracts showing higher activity than aqueous extracts. The antioxidant activity is related to the presence of phenolics and flavonoids. The leaf juice was found to inhibit the formation of skin, liver and colon tumours in tests with mice. A methanolic leaf extract has shown in-vivo anti-inflammatory activity in rats. Petroleum ether, chloroform and hydroalcoholic leaf extracts have shown antimicrobial activity against the Gram-positive bacteria *Bacillus subtilis* and *Staphylococcus aureus*, but not against the Gram-negative bacteria *Escherichia coli* and *Pseudomonas aeruginosa* and the yeast *Candida albicans*. In another study a methanolic leaf extract was active against *Escherichia coli* and *Vibrio cholerae*.

Description Dioecious, coarsely branched, small- to medium-sized tree 12–14 m tall with aerial roots near the base and an open crown; trunk erect or more or less decumbent, up to 20 cm in diameter, grey. Leaves arranged spirally in 3 series, simple, without petiole but with broad clasping base, linear, up to 3 m × 9 cm, apex gradually narrowed to an elongated flagella, margins and dorsal midvein armed with usually forwardly directed, very sharp prickles 5–10 mm long, youngest leaves erect, older ones drooping from the midpoint, glaucous, parallel veins 40–160 but not prominent. Inflorescence unisexual; male inflorescence 30–60 cm long, usually with 5–11 spikes 5–10 cm long; bracts less than 30 cm long; female inflorescence usually with one single head on peduncle 10–30 cm long, bracts subfleshy, navicular with prickly midvein and margins; each head consisting of a mass of 4–10-celled carpels (carpellate phalange). Flowers unisexual, without perianth; male flower a cluster of stamens (staminate phalange), 10–15 mm long, with 19–26 stamens, filaments 0.5–2 mm long, anthers 2–3.5 mm long; carpellate phalange with style absent, stigmas distinct on the apex of each carpel. Fruit an angular drupe up to 5 cm long, arranged in clusters in a globose to ellipsoid, drooping, orange-red syncarp 15–20(–30) cm × 12–18(–20) cm; drupe clusters free from



Pandanus odoratissimus – 1, leaf; 2, male inflorescence; 3, staminate phalange; 4, syncarp; 5, syncarp in schematic longitudinal section; 6, carpellate phalange.
Source: PROSEA

each other but tightly crowded, pentagonal or hexagonal, 3–8 cm × 2–5 cm, composed of 4–10 concentrically arranged, fused carpels. Seeds fusiform to obovoid, 10–12 mm long, retained within the red-brown endocarp, endosperm soft and white.

Other botanical information *Pandanus* includes about 600 species and is found from West Africa eastward to Madagascar, the Indian Ocean islands, India and most of warmer South-East Asia and Pacific islands. From Madagascar c. 80 *Pandanus* species have been reported, and from mainland Africa some 25 species. *Pandanus odoratissimus* belongs to the section *Pandanus*.

Pandanus odoratissimus is closely related to *Pandanus tectorius* Parkinson and the two species may be regarded as West Malesian and Melanesian-Pacific-Australasian vicariants, respectively. According to some taxonomists *Pandanus odoratissimus* is included in *Pandanus tectorius*, but here the view of B.C. Stone is followed that they are separate species. The two species probably hybridize where they meet. *Pandanus odoratissimus* is fairly variable and many varieties and forms have been distinguished. It is notable for its often very large leaf spines, which are generally white or very pale, whereas the leaf spines of *Pandanus tectorius* tend to be fairly small and green. There seems to be, however, a mutant spineless form of *Pandanus odoratissimus* which is very difficult to distinguish from the spineless *Pandanus tectorius* var. *laevis* Warb.

Pandanus kirkii Rendle (Swahili name: mkadi), a tree up to 15 m tall with stilt roots up to 2 m high, usually occurring on sandy beaches and coral just above the high-water mark in Somalia, Kenya and Tanzania is closely related to *Pandanus odoratissimus* and *Pandanus tectorius*. *Pandanus kirkii* can be distinguished from *Pandanus odoratissimus* by its much shorter leaf spines, which are rarely longer than 2.5 mm. Its leaves are used for making baskets, mats, bags and hats. *Pandanus kirkii* is included in the IUCN Red list of threatened species, but it is classified in the 'least concern' category. *Pandanus rabaiensis* Rendle (Swahili name: msanaka) is a tree up to 20 m tall distributed in Kenya and Tanzania. It is used for making mats, baskets and ornaments, and for soil conservation. It is classified as 'near threatened' in the IUCN Red list of threatened species because of its restricted distribution and the decline in extent and quality of its habitat.

In Madagascar various endemic *Pandanus* species are used as fibre plants. The leaves of *Pandanus acanthostylus* Martelli are used for thatching and for making mats, baskets and tents. It is planted as marker of field boundaries. The leaves of *Pandanus concretus* Baker are used for thatching and coarse weaving, e.g. of sacks. They can also be used to make paper. The fruit pulp is eaten. The leaves of *Pandanus pygmaeus* Thouars are used for weaving. It is planted in Mauritius and Réunion, and widely grown and traded as an ornamental plant in other parts of the world. The leaves of *Pandanus sparganioides* Baker are used for fine weaving, and articles woven with material from this species are highly valued in Madagascar.

Growth and development In *Pandanus odoratissimus* planted for kewda products in India, flowering of male plants starts 3–4 years after planting of cuttings or suckers. The inflorescences mature in about 2 weeks.

In several *Pandanus* species, including *Pandanus odoratissimus*, female trees grown far from their native populations produce viable seed, which appear to be apomictic. Syncarps of *Pandanus odoratissimus* can be dispersed by currents because they are buoyant due to the drupes' fibrous mesocarp and the empty space around the seeds. However, germination is reduced by immersion in sea water.

Ecology In its natural distribution area *Pandanus odoratissimus* occurs on sandy beaches, in littoral thickets, on the edges of brackish marshes and mangroves and inland along watercourses at low altitudes. Rainfall should be high. It can grow on a wide range of soils, but heavy, poorly drained loams are not suitable.

Propagation and planting *Pandanus* is usually propagated vegetatively by sucker shoots (axillary branches detached as plantlets), stem segments or full-sized stems. Cleanly removed from the leaf axils, the sucker shoots can be planted straight away or rooted first in a sandy medium. Alternatively, stems with slightly developed prop roots are cut, the leaf crown trimmed but not cut off, and the cuttings inserted obliquely in the medium. *Pandanus* may also be propagated by seed, but seeds should be soaked for 24 hours before planting. Seedlings develop more rapidly from previously weathered drupes or syncarps, which suggests that removal of the exocarp and perhaps scarification of the outer endocarp may accelerate germination. Germination may take several months or even a year for some *Pandanus* species.

The recommended planting distance for *Pandanus odoratissimus* in the Philippines is 2 m × 2 m, with sucker shoots 40–45 cm tall planted out in holes 20–25 cm deep and 15–20 cm wide. However, *Pandanus* is seldom grown in regularly spaced stands, and domestic plantings tend to consist of a few plants intermixed with other species.

Management No information is available on management practices in tropical Africa. In the Philippines it is recommended that plantations of *Pandanus odoratissimus* be weeded every 3 months during the first year after planting and every 6 months during the second and third year, and that organic fertilizer be applied. It is also recommended that dead material be removed to prevent fire, and that old or unproductive trunks and branches be thinned or cut to promote the growth and development of axillary shoots.

Diseases and pests In India a leaf blight caused by *Alternaria alternata* has been recorded. The fungus covers large spots, which turn black, and perforations may appear, leading to premature defoliation and scanty flowering. A leaf blight caused by *Botryodiplodia theobromae* has also been recorded in India, the symptoms being yellowing of older leaves from the tip to the middle and the occurrence of coalescing yellow patches leading to leaf shedding.

Harvesting In Tangerang (West Java) harvesting of *Pandanus odoratissimus* usually starts when plants are 2.5–3 years old, when the leaves are 0.75–1.5 m long. When the plants are about 10 years old, leaf production and quality decrease and they are usually replaced. In Tasikmalaya (West Java), however, trees reportedly remain in use for 60 years without loss of quality. In the Philippines leaf harvesting of *Pandanus odoratissimus* starts at 3 years after planting. Here it is recommended that 8–10 leaves per branch per month be harvested and that good quality, middle-aged, uniformly light green leaves be selected. In India the male inflorescences of *Pandanus odoratissimus* are simply plucked by breaking them off using a hook attached to a stick.

Yield No information exists on leaf or fibre yields of *Pandanus odoratissimus*. In India mature plants produce approximately 15–40 male inflorescences per plant per year. From 1000 inflorescences about 18 kg of kewda water is obtained, whereas about 100,000 inflorescences are needed to produce 1 kg of kewda oil, as the oil yield is only 0.03%.

Handling after harvest For the production of weaving material from *Pandanus odoratissimus* a leaf is usually cut, dried slightly, and the marginal spines, where present, are removed. The leaves are then split into two by removing the midrib, and the halves are cut into strips. These strips are then made supple by pulling them over a bamboo, or by rolling or beating. Then they may be soaked in water, after which they are bleached in the sun. They may be dyed, often with simple stains such as crystal violet, resulting in colourful and multicoloured articles.

Kewda attar is prepared from *Pandanus odoratissimus* by distilling the ripe inflorescences for 4–5 hours. Prior to distillation, the bracts are removed from the fresh inflorescences. About 500–1000 inflorescences, each cut into 3–4 pieces, are put in a large copper still and water is added (60 l per 1000 inflorescences). The vapour is absorbed in sandalwood oil. Several grades are prepared depending on the number of inflorescences distilled per kg sandalwood oil, normally 1000–10,000, but sometimes up to 100,000. For cheaper grades, refined liquid paraffin ('white oil') is sometimes used instead of sandalwood oil. It is not only cheaper, but also absorbs more kewda aroma per inflorescence than sandalwood oil. However, the aroma retention is worse. Ripe, cream-coloured inflorescences give higher perfume yields of better quality than immature ones. Kewda water is obtained by simply distilling the inflorescences in water only. Kewda oil is very soluble in water and cannot be separated from the distillate by ordinary physical means. It may be prepared by extracting the flowers with a solvent, precipitating the fatty matter with alcohol and distilling the absolute under reduced pressure.

Genetic resources No germplasm collections of *Pandanus odoratissimus* are known.

Prospects In Asia *Pandanus odoratissimus* is an important source of weaving material and widely used for flavouring and perfumes. In tropical Africa it is much less important, being only occasionally cultivated for its fibrous leaves and fragrant inflorescences, and there is little reason to expect that it will become more important in the future. The prospects for *Pandanus odoratissimus* as a source of kewda products in India are promising.

Major references Balfour, 1877; Beentje, 1993; Boiteau, Boiteau & Allorge-Boiteau, 1999; Bosser & Guého, 2003; Brink & Jansen, 2003; Kumar et al., 2010; Londonkar, Kamble & Reddy, 2010; Purseglove, 1972; Sasikumar, Jinu & Shamna, 2011; Stone, 1973.

Other references Bailey & Bailey, 1976; Beentje, 1994b; Brown et al., 2009; Eastern Arc Mountains & Coastal Forests CEPF Plant Assessment Project Participants, 2008; Huxley (Editor), 1992c; Laivao, 2008; Laivao, Callmander & Buerki, 2007; Lean Teik Ng & Su Foong Yap, 2003; Martin et al., 2009; Panda et al., 2007; Stone, 1970; Thulin, 1995c; Wei et al., 2008.

Sources of illustration Brink & Jansen, 2003.

Authors P. Oudhia

PANDANUS UTILIS Bory

Protologue Voy. îles Afrique 2: 3 (1804).

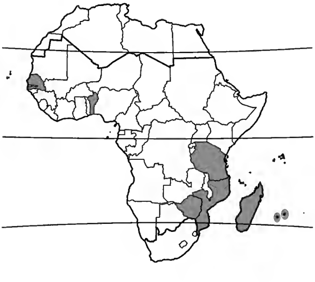
Family Pandanaceae

Chromosome number $2n = 60$

Synonyms *Vinsonia utilis* (Bory) Gaudich. (1841).

Vernacular names Common screw pine (En). Vacoa, baquois, vaquois (Fr). Pandano (Po). Mkadi (Sw).

Origin and geographic distribution The origin of *Pandanus utilis* has long been considered to be Madagascar, but more recently it has been suggested that it may have originated in the Mascarene Islands. It has been in cultivation for at least 200 years and is known to be grown in Senegal, Benin, Tanzania, Zimbabwe, Mozambique, Madagascar, Réunion and Mauritius. It has been introduced to many tropical and subtropical regions, mainly as an ornamental, e.g. in Central America, the Caribbean, the United States (southern Florida, Puerto Rico), Brazil, India and Indonesia. No wild populations are known.



Pandanus utilis – planted

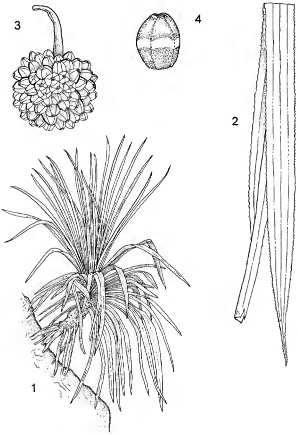
Uses The leaves of *Pandanus utilis* are used, mainly in Madagascar, Réunion and Mauritius, for thatching and for the production of ropes, baskets, mats, hats, place mats and nets. They can also be used to make paper. In Mauritius and Réunion, sugar bags were made from the leaves. The aerial roots have been used for tying and in the production of baskets, mats and hats, and their ends to make coarse brushes for whitewashing.

The fruits form a starchy food, palatable after cooking. Cooked male inflorescences are also eaten and are considered to have aphrodisiac properties. The terminal bud or 'cœur de vacoa' is consumed as a vegetable in Réunion. Root decoctions are taken against venereal diseases. In Mauritius a root decoction is recorded to be taken in cases of fish poisoning and as an aphrodisiac, and a decoction of the fresh leaves mixed with wood and charcoal of *Hilsenbergia petiolaris* (Lam.) J.S.Miller (synonym: *Ehretia petiolaris* Lam.) is applied to the forehead for the treatment of migraine. In Réunion, *Pandanus utilis* trees are used as support for vanilla (*Vanilla planifolia* Andrews). The trees serve as windbreaks mainly along the shore. *Pandanus utilis* is a well-known ornamental in many tropical and subtropical regions. In temperate parts of the United States and Europe young *Pandanus utilis* are grown as indoor foliage plants.

Production and international trade No data on production or trade are available. In Mauritius the expanding tourist industry provides considerable demand for local handicraft products based on *Pandanus utilis* and other fibre yielding plants, such as *Furcraea foetida* (L.) Haw. and *Phoenix dactylifera* L.

Properties The leaves of young unbranched trees are suitable for the production of bags, mats etc. because they are long and supple, whereas the leaves of older, branched trees are too short and rigid.

Description Dioecious small- to medium-sized tree up to 20 m tall, with a smooth, branched trunk and many pale brown basal aerial roots 2.5–7.5 cm in diameter; branches with annular leaf scars. Leaves arranged spirally in 3 series, crowded towards the top of stems, simple, without petiole but with broad clasping base, linear, up to 2 m long, but shorter on old trees, 3–11 cm broad, tapering in a



Pandanus utilis – 1, plant habit; 2, leaf; 3, fruiting head; 4, fruit.
Redrawn and adapted by W. Wessel-Brand

long point at apex, margins and ribs beneath reddish-brown with many sharp, ascending, reddish, 1–4 mm long spines, stiff, erect, with many parallel longitudinal veins. Inflorescence unisexual; male inflorescence a branched spadix 30–80 cm long, in the axil of a pale spathe; female inflorescence a subglobose head of densely crowded ovaries. Flowers unisexual, without perianth; male flowers odorous, with 8–12 stamens inserted pseudo-umbellately on slender columnal excrescences 10–15 mm long; female flowers with 3–8-celled ovary crowned by a sessile stigma. Fruit a dome-shaped, compressed, angular drupe arranged in a pendulous, long-peduncled, subglobose syncarp 15–20 cm in diameter, consisting of up to 200 drupes, each up to 3.5 cm × 4 cm × 2 cm, yellow when ripe, upper half free, base with a purple or red band; pyrene 3–8-celled, containing several seeds. Seeds endospermous, retained within the endocarp.

Other botanical information *Pandanus* includes about 600 species and is found from West Africa eastward to Madagascar, the Indian Ocean islands, India and most of warmer South-East Asia, Australia and the Pacific islands. From Madagascar c. 80 *Pandanus* species have been reported, and from mainland Africa some 25 species. *Pandanus utilis* belongs to the section *Vinsonia*. Another species in this section is *Pandanus heterocarpus* Balf.f., a shrub or small tree up to 7 m tall endemic to Rodrigues. The leaves of young *Pandanus heterocarpus* plants are used for weaving, and the trunks of older ones are used in construction. The fruits are recorded to be unpalatable. Recorded medicinal uses are quite similar to those of *Pandanus utilis*: a root decoction is taken in cases of fish poisoning, a decoction of young leaves is taken as an aphrodisiac, and a decoction of the fresh leaves mixed with wood and charcoal of *Hilsenbergia petiolaris* is applied to the forehead for the treatment of migraine.

Anatomy Transverse sections of stems of *Pandanaceae* can be distinguished from those of other monocotyledons by the frequent presence of compound vascular bundles, consisting of 2 or 3 conducting strands enclosed by a common bundle sheath. The phloem parts of the separate strands are oriented towards each other, which means that only 1 strand has the normal orientation. As in other species of the section *Vinsonia*, the leaves of *Pandanus utilis* have a spongy tissue with abundant fibres in bundles; these bundles may contain over 150 fibres.

Growth and development Seed germination is slow and takes 2–3 months at a soil temperature of at least 27°C.

Ecology *Pandanus utilis* is salt tolerant and grows well near the sea. In Réunion it is especially common near the coast.

Propagation and planting *Pandanus utilis* can be propagated by seeds, but these are recalcitrant. Pre-soaking of the seeds for 24 hours before sowing is recommended for *Pandanus* in general. The germination rate is usually over 50%. Seedlings emerge about 4 months after sowing. After 12–16 months they are 20–40 cm tall and ready to be planted out. Propagation by stem cuttings and suckers is also possible. In Réunion, planting in April or May at spacings of 1.5–3 m is recommended.

Management Pruning and shaping should be done with care, as branches do not have dormant buds. When the terminal growing area is cut off, the branch will not grow further.

Harvesting In Réunion, harvesting of leaves starts when plants are 3–4 years old, and may continue for about 20 years.

Genetic resources No germplasm collections of *Pandanus utilis* are known. The genetic diversity of the cultivated plants is unknown and deserves more attention in the absence of natural populations.

Prospects The importance of *Pandanus utilis* in Africa will remain limited, but its combined use as a fibre plant and windbreak in coastal regions may offer some prospects. The niche market for handicraft products made from *Pandanus utilis* may grow with increasing tourism to countries such as Mauritius.

Major references Bosser & Guého, 2003; Burkill, 1997; de Cordemoy, 1895; Little, Woodbury & Wadsworth, 1974; Sarrailh et al., 2007; Stone, 1970; Stone, 1973; Stone, 1974; Stone, 1991; Vaughan & Wiehe, 1953.

Other references Bailey, 1947; Bailey, 1951; Bailey & Bailey, 1976; Balfour, 1877; Beentje, 1993; Berhaut, 1967; Cheah & Stone, 1973; CSIR, 1966; de Souza, 1987; Gurib-Fakim & Brendler, 2004; Gurib-Fakim et al., 1994; Hanelt & Institute of Plant Genetics and Crop Plant Research (Editors), 2001; Huxley (Editor), 1992c; Huynh, 1977; Huynh, 1979; Miguet, 1955; Pilonchéry, 1999; Purseglove, 1972; Stone, 1983; Zimmermann, Tomlinson & LeClaire, 1974.

Sources of illustration Little, Woodbury & Wadsworth, 1974; Kerner von Marilaun, 1887.

Authors M. Brink

PARARISTOLOCHIA PROMISSA (Mast.) Keay

Protologue Kew Bull. 1952: 160 (1952).

Family Aristolochiaceae

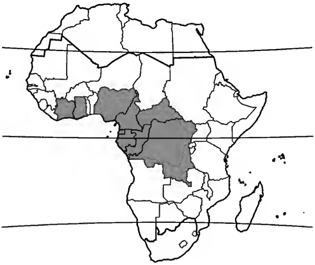
Synonyms *Aristolochia promissa* Mast. (1879), *Aristolochia flagellata* Stapf (1906), *Aristolochia congolana* Hauman (1948), *Pararistolochia tenuicauda* (S.Moore) Keay (1952), *Pararistolochia talbotii* (S.Moore) Keay (1952).

Origin and geographic distribution *Pararistolochia promissa* occurs from Côte d'Ivoire eastward to the Central African Republic and DR Congo.

Uses In DR Congo the stems are made into snares and traps for small mammals.

Production and international trade *Pararistolochia promissa* is only used locally.

Botany Perennial, woody climber; stems up to 30 m long and often thin but up to 25 cm in diameter at the base, laterally strongly flattened to bilobed in cross-section, branched from the base, glabrous. Leaves alternate, simple and entire; petiole 2–5 cm long, slender; blade oblong-elliptical, obovate or broadly ovate, 8–15 cm × 4–9 cm, acute, obtuse or cuneate at the base, cuspidate or acuminate at the apex, membranous to leathery, glabrous. Inflorescence a helicoid cyme, in the axils of old or fallen leaves, mostly 2–3(–6) together on knobby outgrowths on old stems almost from the ground to the top, 2–4 cm long, bearing up to 10 aborted buds and apically 2–4 flowers. Flowers trumpet-shaped, smelling unpleasantly when open; perianth up to 12.5 cm long exclusive of the tails, greenish-white, glabrous, base globose, up to 2.5 cm × 1–2 cm, tube broadly funnel-shaped, up to 3 cm × 0.5–2 cm, lobes 3, triangular, unequal, with the lateral ones prominent and the median one reduced, variable in size, with filiform pendulous tails up to 60 cm long, inside light yellow, brown-spotted and with white hairs, outside dirty yellow; stamens 9–12, linear-oblong, scarcely reaching to the base of the column; ovary inferior, style-branches 9–12, oblong, obtuse, abruptly acuminate. Fruit a berry up to 20(–30) cm long, with 6 rounded ridges.



Pararistolochia promissa – wild

Pararistolochia comprises about 9 species in Africa and about 9 Australasia. It is closely related to *Aristolochia* and often considered a subgenus of the latter.

Ecology *Pararistolochia promissa* grows at 350–1500 m altitude in forest, sometimes in plantations.

Management *Pararistolochia promissa* is only collected from the wild.

Genetic resources and breeding *Pararistolochia promissa* is widespread and locally common. There are no indications that it is in danger of genetic erosion.

Prospects *Pararistolochia promissa* is likely to remain of incidental use only.

Major references Baker & Wright, 1909–1913; Burkill, 1985; Keay, 1952; Poncy, 1978; Wanke, González & Neinhuis, 2006.

Other references González, 1999; Hauman, 1948a; Huber, 1985; Huber, 1993; Irvine, 1961; Jongkind, 1990; Keay, 1954a; Kelly & González, 2003; Ma, 1992; Neinhuis et al., 2005.

Authors L.P.A. Oyen

PAROPSIA PERRIERI Claverie

Protologue Ann. Mus. Colon. Marseille 7: 59 (1909).

Family Passifloraceae

Origin and geographic distribution *Paropsia perrieri* is endemic to the northern-most part of Madagascar.

Uses Fibres from *Paropsia perrieri* are used in textile fabrics, although they are not very durable.

Botany Shrub or small tree up to 15 m tall; bole up to 25 cm in diameter; branches ferruginous-tomentose, lateral ones always longer than terminal one, hairy when young. Leaves alternate, distichous, short-lived; petiole thin, 5–8 mm long; blade broadly oblong, (3.5–)5–10 cm × (2–)2.5–4(–6) cm, base rounded, apex tapering, margin entire or somewhat toothed, papery to thin-leathery, both surfaces shortly ferruginous-tomentose, lateral veins in 8–10 pairs. Inflorescence an axillary cyme 2–10 mm long, on specialized branches bearing leaves, long-pedunculate, (1–)2–4-flowered; bracts linear, 4–5 mm long; flowers bisexual, fragrant; pedicel 10–25 mm long; sepals 5, oblong, 10–12 mm × 4–5 mm, shortly connate at base, apex obtuse, reddish tomentose outside, white to greyish velvety inside; petals 5, narrowly oblong, 8–10 mm × 3.5–4.5 mm, thinner than sepals, white, velvety on both surfaces; corona laciniate, 2.5 mm long, in bundles in front of the petals; stamens 5, filaments 5–6 mm long, anthers c. 2.5 mm long; ovary on a 12 mm long reddish hairy gynophore, obovoid, 1-celled, styles c. 3, 1.5–2 mm long, free, with thick stigmas. Fruit a nearly globose 3-valved capsule 12–15 mm in diameter, tomentose. Seed compressed ovoid, 5–7 mm × 1–2 mm, with thin, entire, fleshy aril. Seedling with epigeal germination.

Paropsia perrieri flowers in October–November.

Paropsia comprises 12 species, of which 5 occur in mainland tropical Africa, 6 in Madagascar and 1 in South-East Asia.

Ecology *Paropsia perrieri* is rather rare in dry deciduous forest, at low altitudes.

Management *Paropsia perrieri* only occurs wild.

Genetic resources and breeding *Paropsia perrieri* occurs only in a small part of Madagascar. It is also rare and therefore at risk of genetic erosion.

Prospects It is unlikely that *Paropsia perrieri* will become an important source of fibre.

Major references Decary, 1946; Perrier de la Bâthie, 1945; Sleumer, 1970.

Other references Medina, 1959; Missouri Botanical Garden, undated.

Authors L.P.A. Oyen

PAVONIA URENS Cav.

Protologue Diss. 3: 137 (1787).

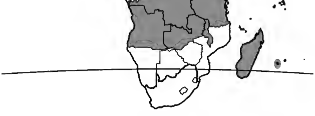
Family Malvaceae

Chromosome number $2n = 56$

Synonyms *Pavonia bojeri* Baker (1882), *Pavonia ruwenzoriensis* De Wild. (1922).

Origin and geographic distribution *Pavonia urens* is widely distributed in tropical Africa, from Guinea disjunctly eastwards to Ethiopia and Eritrea and southwards to Tanzania, Zambia and Angola. It also occurs in Madagascar and Réunion.

Uses The bark is commonly used for making string and cordage. In Kenya the bark is used for making baskets. The wood is used for roof rods and as fuelwood. The leaves are browsed by sheep and goats, and are fed to calves. In



Pavonia urens – wild

Kenya the leaves are used for cleaning the hands and utensils, and they are used as toilet paper for infants. The flowers may be cooked as a vegetable. The plant has ornamental value.

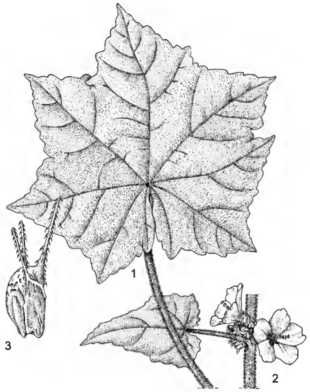
Pavonia urens is widely used in African traditional medicine. In DR Congo the scraped and softened root is applied on wounds, and the leaves are boiled in water after which the warm leaf is used to pat the eyes in case of weak eyesight. In Burundi the pounded roots and leaves are applied as dressings on fractures and dislocations, a decoction of the roots and leaves is given for the treatment of diarrhoea in babies, a leaf decoction is taken against cough and insanity, a leaf infusion is drunk against nausea and abdominal pain during pregnancy and leaf powder is taken as an oxytocic. In case of sterility, sap from leafy twigs is used as a wash and pulverized leaves are taken. In Ethiopia root powder is taken orally against impotence, and leaf preparations are applied on ulcers. In Tanzania root preparations are taken for the treatment of stomach problems and pneumonia; the crushed leaf is also taken against stomach problems. In Madagascar the root is used against stomach-ache and a decoction of the aerial parts is inhaled in case of fever.

Properties Fibre strands from Uganda investigated in the 1950s were pale green to greyish cream and 1–2.5 m long. The ultimate fibres were (1.3–)2.2–2.5(–6.2) mm long and (12–)17.4–19.4(–30) μm in diameter, with a cell wall thickness of (4.3–)7.6–8.9(–12.9) μm and an average lumen width of 1.5 μm. The tensile strength of the dry fibre was 54.9–66.2 kg/mm^2. The fineness and strength of the fibre compared unfavourably with jute fibre, and the quality more resembled that of kenaf (*Hibiscus cannabinus* L.) fibre.

Methanol, ethyl-acetate and water extracts of the root have shown antifungal and antibacterial activity.

Adulterations and substitutes Many other *Malvaceae* are used for making cordage, for instance *Triumfetta cordifolia* A.Rich. and *Urena lobata* L.

Description Shrubby herb or shrub up to 3(–4.5) m tall; branches and leaves bearing irritating stellate and simple hairs, rarely glabrescent. Leaves alternate, simple, stipules linear to lanceolate; petiole up to 23 cm long; blade cordate to reniform in outline, shallowly to deeply 3–7-lobed, 4.5–23 cm × 5.5–24 cm, lobes triangular, acute to acuminate at the apex, or some leaves narrowly triangular and cordate at the base or lanceolate, margin coarsely toothed; upper surface densely pilose to velvety with simple and stellate hairs, lower surface densely pilose to velvety. Flowers solitary in leaf axils or in dense clusters, forming spike-like panicles, bisexual, regular; pedicel up to 8 mm long; epicalyx bracts 8–10, linear, 5–11 mm × 0.5–1 mm, appressed to calyx; calyx 5-lobed, 6–8 mm long, with long simple hairs; petals 5, free but adnate to the base of the staminal column, 15–35 mm long, pink to red or purple, darker at the base; staminal column truncate, 10–20(–26) mm long; ovary superior, style branches 10. Fruit a subglobose schizocarp of 5 follicle-like sections (mericarps); mericarps 5–6 mm long, with 3 apical, retrorsely barbed awns (3–)5–8 mm long. Seeds reniform, 3–4 mm long, brown.



Pavonia urens – *1, leaf; 2, part of flowering branch; 3, mericarp.*
Redrawn and adapted by Achmad Satiri Nurhaman

Other botanical information *Pavonia* comprises c. 200 species, distributed in the tropics and subtropics, the largest number in South America. *Pavonia schimperiana* Hochst. ex A.Rich. is a shrubby herb or shrub up to 3.5(–5) m tall, distributed from Côte d'Ivoire eastwards to southern Sudan and Ethiopia, and southwards to DR Congo, Tanzania and Angola. In Eritrea and Ethiopia fibre from the bark is used for cordage. It is sometimes considered as conspecific with *Pavonia urens*, but is easily distinguished by its white petals with dark red or purple base. *Pavonia burchellii* (DC.) R.A.Dyer is a shrubby herb or shrub up to 2 m tall, distributed from Cameroon eastwards to Ethiopia and Eritrea and southwards through East Africa to South Africa. It also occurs in Arabia. In Rwanda in the 1950s fresh, defoliated stems collected from the wild yielded 2.7–2.9% fibre after 8–9 days of retting. The fruit is said to be edible. In Uganda a paste of pounded leaves is dried and pulverized and taken for the treatment of infrequent menstruation. In southern Africa root decoctions are taken for the treatment of stomach problems and chest pain, and to increase virility. *Pavonia senegalensis* (Cav.) Leistner (synonym: *Pavonia hirsuta* Guill. & Perr.) is a perennial herb or shrub up to 125 cm tall. It is widely distributed in the drier parts of tropical Africa, from Senegal eastwards to Sudan and southwards to Namibia, Botswana and South Africa. In Cameroon the bark is used as rough cordage. In West Africa fibre from the bark is spun into fishing-tackle. Straight stems are used as arrow-shafts. The mucilaginous root is added to milk for acceleration butter production during churning. Mucilage from the root is mixed with mud and used for daubing hut-walls. In Namibia the root is used for tanning leather for skirts. The roots are used in preparations for the treatment of diarrhoea, syphilis and venereal discharges. In Botswana a cold water infusion of the dry root is taken to induce labour and ease delivery. The plant has ornamental value.

Growth and development In West Africa flowering is in September–January, in Tanzania in April and in Réunion in March–July.

Ecology *Pavonia urens* occurs at 600–3000(–3500) m altitude, in forest margins and clearings, riverine forest, swamp forest, bushland, grassland, secondary vegetation, abandoned farmland, along roads and in waste places. It is also a weed in farmland.

Propagation and planting *Pavonia urens* is collected from the wild. The 1000-seed weight is 12–17 g.

Yield In Rwanda in the 1950s fresh, defoliated stems collected from the wild yielded 3.0% fibre after 7 days of retting, while in planting experiments yields were obtained of 1136 kg fibre per ha, with the fresh, defoliated stems yielding 3.8% fibre after 11 days of retting.

Handling after harvest In Uganda the retting time needed is 7–15 days. In Madagascar the stems and large branches are retted for 2–3 days until the bark is easy to remove. The bark is then beaten on a stone to free the fibre, which is washed with soap. After being dried in the shade the fibre is ready to be spun.

Genetic resources In view of its widespread distribution and wide range of habitats, including disturbed locations, *Pavonia urens* is not threatened with genetic erosion.

Prospects *Pavonia urens* is a useful local source of cordage fibre. It is unlikely to become of commercial importance, because of the quality of the fibre and the presence of irritating hairs on the plant.

Major references Burkill, 1997; de Boer et al., 2005; Feuell & Jarman, 1951; Kirby, 1963; Latham, 2007; Lejeune, 1953; Neuwinger, 2000; Thulin, 1999a; Verdcourt & Mwachala, 2009; Vollesen, 1995a.

Other references Abbiw, 1990; Auquier & Renard, 1975; Beentje, 1994a; Decary, 1946; Hauman & Wouters, 1963; Ichikawa, 1987; Irvine, 1961; Jansen, 1981; Keay, 1958d; Kokwaro, 1993; Liu et al., 2008b; Marais & Friedmann, 1987; Mauersberger (Editor), 1954; Maundu et al., 2001; Medina, 1959; Rasoanaivo et al., 1992; Ravaoarimanana, 2005; Teklehaymanot & Giday, 2007; van Wyk & Gericke, 2000; Yamada, 1999.

Sources of illustration Vollesen, 1995a.

Authors V.A. Kémeuzé & B.A. Nkongmeneck

PEDDIEA AFRICANA Harv.

Protologue Journ. Bot. (Hooker) 2: 266 (1840).

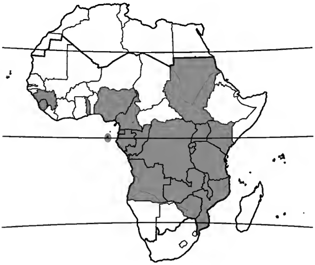
Family Thymelaeaceae

Synonyms *Peddiea fischeri* Engl. (1892).

Vernacular names Cord tree, poison olive, green flower tree, fibre-bark tree (En).

Origin and geographic distribution *Peddiea africana* is distributed in Guinea, Sierra Leone, Togo and from Nigeria eastward to Kenya and southward to Angola, Zimbabwe and Mozambique. It also occurs in eastern South Africa and in Swaziland.

Uses The fibrous bark of *Peddiea africana* is widely used for tying. Extracted fibres are used for making ropes and cords throughout its area of distribution. In Tanzania the wood is used for making spear-shafts and it is appreciated as firewood and for charcoal making. In Guinea the fruit is eaten. In Cameroon it is planted to demarcate land, as a live fence, and the wood is



Peddiea africana – wild

used for timber and as firewood. The roots are poisonous and have been used in homicide. In Uganda a necklace made of the bark is supposed to be a cure for heartburn. *Peddiea africana* is planted as an ornamental.

Properties Like several other species in the genus, *Peddiea africana* contains compounds that irritate the skin, and contact with the skin can lead to severe allergic reactions. The toxicity of the roots is probably caused by a diterpenoid ester of the daphnane type that is known for its anticancer effects. A quinone (2,6-dimethoxybenzoquinone) and two coumarins (daphnoretin and umbelliferone) have been isolated from the root. The quinone is known to have antimicrobial properties and has shown anticancer effects.

Botany Densely branched shrub up to 4 m tall or small tree up to 6(–10) m tall; outer bark smooth, brownish, inner bark pale pink to red; branches glabrous. Leaves alternate, simple and entire; stipules absent; petiole 2–6 mm long; blade elliptical, lanceolate to oblanceolate, 5–16.5 cm × 2–5 cm, tapering or obtuse at the base, obtuse to acute at the apex, membranous to leathery, glabrous. Inflorescence terminal, umbellate, (3–)5–22-flowered; peduncle up to 5 cm long. Flowers bisexual, regular, 5-merous, yellowish green; pedicel 3–8 mm long; calyx tube cylindrical, 6–15 mm long, glabrous, lobes ovate, up to 4 mm × 2 mm, glabrous or sometimes with a few hairs at the apex; petals absent; stamens 10, in 2 whorls of unequal length, inserted in the throat of the calyx tube, almost sessile; ovary superior, shortly stalked, 2-locular, style filiform, up to 4 mm long, disk cup-shaped. Fruit an ovoid drupe up to 15 mm × 10 mm, reddish to black, glabrous or densely hairy at the top, 1(–2)-seeded.

In southern Africa *Peddiea africana* flowers from September to February and mature fruits are present from February to October.

Peddiea comprises 9 species, distributed in tropical Africa, with 1 of these species endemic to Madagascar. Until recently, *Peddiea africana* and *Peddiea fischeri* Engl. were thought to be 2 distinct species. The former was supposed to be restricted to Zimbabwe, Mozambique, South Africa and Swaziland. The 2 were distinguished by glabrous ovary/fruit and disk versus hairs on top of ovary/fruit and disk and minute differences in the calyx tube. However, in Zimbabwe and Mozambique, where both are indigenous, intermediates occur and there is no basis to keep distinguishing 2 separate species.

Peddiea rapaneoides Gilg. ex Engl. (synonym: *Peddiea orophila* A.Robyns) is distributed in eastern DR Congo and neighbouring Rwanda and Burundi and occurs in forests at 1600–3000 m altitude. Fibres from its bark are used for making rope.

Ecology *Peddiea africana* occurs at 750–2400 m altitude in forest understorey, forest margins, riverine bushland and thickets. In West Africa it is considered a species of montane forest.

Management *Peddiea africana* produces fruits abundantly, and these can be harvested easily. Seeds can be stored in a cool place in sealed containers. Seed treatment before sowing is not necessary. Propagation can be done with seed, wildlings or cuttings. Trees can be coppiced or pollarded.

Pole cuttings are planted to make living fences in western Cameroon. The function of the living fences determines the length of the cuttings planted and their spacing, the structure of the fence, and its latticing with raffia. Pollarding the trees in the fence every 3–4 years supplies the family with their wood requirements, including cuttings for repairing the fence.

Genetic resources and breeding As *Peddiea africana* is very widespread and common, it is not threatened with genetic erosion.

Prospects In Uganda it is considered feasible to grow *Peddiea africana* as a plantation crop for fibre production. However, as quantitative information on the fibre properties is lacking, it seems useful to investigate these first. The plant contains compounds with anticancer and toxic properties, and more research on its phytochemistry seems useful as well.

Major references Breteler, 1994; Burkill,

2000; Coates Palgrave, 1983; Peterson, 2006; Temu, 1990.

Other references Gautier, 1995; Gelfand et al., 1985; Hamill et al., 2000; Handa et al., 1983; Hawthorne & Jongkind, 2006; Katende, Birnie & Tengnäs, 1995; Robyns, 1975; Staner, 1935; Tahara & Ingham, 2000; van Wyk, van Heerden & van Oudtshoorn, 2002.

Authors C.H. Bosch

PHACELURUS GABONENSIS (Steud.) Clayton

Protologue Kew Bull. 35(4): 817 (1981).

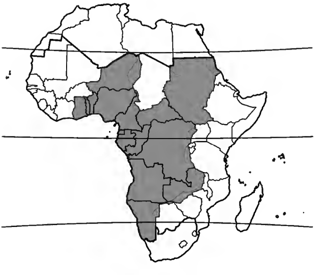
Family Poaceae (Gramineae)

Chromosome number $2n = 18, 20$

Synonyms *Jardinea gabonensis* Steud. (1854), *Rhytachne congoensis* Hack. (1889), *Rhytachne gabonensis* (Steud.) Hack. (1889), *Jardinea congoensis* (Hack.) Franch. (1895), *Rottboellia gabonensis* (Steud.) Roberty (1960), *Phacelurus congoensis* (Hack.) Zon (1992).

Origin and geographic distribution *Phacelurus gabonensis* is distributed from Ghana eastward to Sudan and southward to Zambia and Angola. It is occasionally planted.

Uses The stems are commonly used for making baskets, mats, screens, fish traps, grain containers and covers. In Nigeria they are used for thatching, fencing and for making beehive frameworks which are plastered with a filler. In the Central African Republic the stems are used for making enclosures around houses, as splints in case of bone fractures and as arrow shafts. Root pieces are worn by women as a perfume. Young plants are browsed. In Cameroon *Phacelurus gabonensis* is planted to mark field boundaries. In traditional medicine in the Central African Republic root decoctions are given to children with colic and taken for the treatment of blennorrhoea. The fresh root is pulped to a mash which is applied as a poultice on the stomach for the treatment of intestinal pain. Sap from pounded roots is put up the nostrils to stop nose bleeding.



Phacelurus gabonensis – wild and planted

Properties The root is fragrant.

Botany Robust, tufted, perennial grass with cane-like stems up to 3.5 m tall. Leaves simple; basal sheath broad and papery but not flabellate; ligule a ciliate membrane; blade linear, up to 60 cm × 12 mm, flat or loosely inrolled. Inflorescence terminal, up to 35 cm long, consisting of 4–14 digitate racemes borne along a central axis up to 15 cm long; racemes 15–25(–30) cm long, occasionally some of them branched; internodes and pedicels linear, subclavate upwards, smooth or scabrid. Spikelets in pairs, 1 sessile and 1 pedicelled; sessile spikelet fertile, 2-flowered, lanceolate, dorsally compresssed, 4–8 mm long, yellowish-green or purplish, callus truncate, with a short central peg, glumes 2, lower glume lanceolate, 4–8 mm long, acuminate to apiculate or mucronate at the apex, chartaceous, flat across the back, faintly to prominently veined, upper glume lanceolate, lower floret male or sterile, with hyaline lemma and without palea, upper floret bisexual, with lanceolate, hyaline, awnless lemma and hyaline palea, lodicules 2, stamens 3, stigmas 2; pedicelled spikelet sterile, often smaller than sessile one or even almost suppressed, rigidly apiculate at the apex, with a short callus, glumes subequal, lemmas 0–2. Fruit a caryopsis (grain), oblong, dorsally compressed.

In Benin *Phacelurus gabonensis* flowers in August–October.

Phacelurus comprises c. 10 species, distributed in the Old World tropics and subtropics.

Ecology *Phacelurus gabonensis* occurs from sea level up to 1100 m altitude in swampy locations, seasonally wet grassland and forest edges, and along streams.

Management Stems are usually harvested when 2–3 years old. The harvested stems are dried in the sun, after which they may be cut in pieces for the manufacture of baskets and other woven items.

Genetic resources and breeding In view of its wide distribution *Phacelurus gabonensis* is unlikely to be threatened with genetic erosion.

Prospects *Phacelurus gabonensis* is a useful local source of material for weaving and thatching. Although it is recorded to be planted, which indicates that it is valued, very little information is available on its properties and management practices.

Major references Burkill, 1994; Clayton et al., 2002–; Cope, 2002; Koechlin, 1962; Vergiat, 1970b.

Other references Aiyedun & Oyerinde, 1998; Akoègninou, van der Burg & van der Maesen, 2006; Apema, 1995; Bikoumou, 1998; Boutrais, 1987; Clayton, 1972; Clayton & Renvoize, 1982; Dujardin, 1978; Germain, 1965; van der Zon, 1992.

Authors N.S. Alvarez Cruz

PHOENIX RECLINATA Jacq.

Protologue Fragm. Bot. 1: 27 (1801).

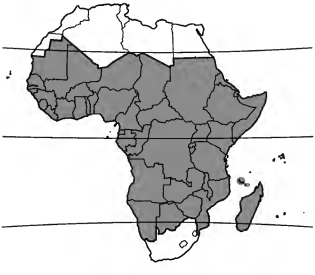
Family Arecaceae (Palmae)

Chromosome number $n = 18$

Synonyms *Phoenix abyssinica* Drude (1895), *Phoenix comorensis* Becc. (1906).

Vernacular names Wild date palm, Senegal date palm, swamp date palm, false date palm (En). Dattier sauvage, dattier du Sénégal, dattier nain du Sénégal, dattier de marais, faux dattier (Fr). Palmeira da tara (Po). Mkindu (Sw).

Origin and geographic distribution *Phoenix reclinata* is distributed throughout sub-Saharan Africa, from Senegal and Gambia eastwards to Somalia and southwards to South Africa and Madagascar. It also occurs in Egypt, Saudi Arabia and Yemen. *Phoenix reclinata* is widely planted as an ornamental in tropical and subtropical regions, also outside tropical Africa.



Phoenix reclinata – wild and planted

Uses The leaflets or strips of the leaflets of young, unexpanded leaves are widely used for making mats, bags, baskets, hats, sieves, rope, string, fishing nets, traps, parasols and ornaments. Strips from mature leaves are used for weaving hats. The split petiole and rachis of mature leaves are used in coarse weaving, e.g. of baskets, mats and fish traps, and for tying. The whole rachis is used for making huts and fish kraals. The Maasai use the rachis for cleaning gourds. The leaves are used for thatching and as fans. Hand brooms are made from the stem by pounding its end until the fibres separate. Dried inflorescences are also used as brooms.

The trunk, although often bent, is much used in the construction of huts, houses, fences, bridges, landing-stages, traps and hives. In Ghana the wood is made into drums. The wood is also used as fuelwood and is suitable for charcoal production. The base of the stem is sometimes eaten. The palm is tapped for sap to be fermented into a palm wine. The apical bud is eaten as a vegetable ('palm cabbage'); it is said to be slightly bitter. The ripe fruits are eaten, sometimes after having been immersed in boiling water for a moment. In Sierra Leone the kernels are parched and ground into flour for consumption. Roasted seeds are used as a coffee substitute. The roots yield an edible gum and contain tannins. In Kenya and Tanzania a brown dye is obtained from the root. *Phoenix reclinata* is widely planted as an ornamental and locally for shade and amenity. The leaves and petioles are used for dune fixation.

In traditional medicine in Senegal root macerations are considered astringent and taken for the treatment of stomach-ache and diarrhoea, a decoction of the apical bud is used in baths and draughts against tiredness, and preparations of the leaflets are externally applied for the treatment of eye diseases. In Côte d'Ivoire the fruit is used for the treatment of female sterility. In Uganda the pounded roots mixed with banana juice or beer are taken against gonorrhoea and impotence, and fresh leaves are chewed and swallowed against abdominal pain. In Tanzania a root decoction is drunk against epilepsy.

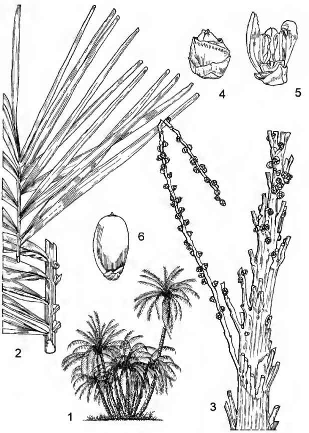
In various countries the leaves have ceremonial uses. In Senegal they are made into loincloths to be worn at circumcision ceremonies. In Ethiopia the leaves are used on Palm Sunday in the Orthodox Church and as decorations for weddings. Between Palm Sunday and Easter children use the young soft leaflets for making finger rings.

Production and international trade The leaves and woven products made from them are locally sold in markets.

Properties Mats and baskets made from the leaflets of *Phoenix reclinata* are very durable. The wood is pale brown, and has an air-dry density of 590 kg/m^3. It is durable and resistant to attacks by termites and fungi.
The fruit is smaller than and inferior to that of the true date palm (*Phoenix dactylifera* L.). The fruit flesh contains per 100 g edible portion: moisture 36.1 g, energy 858 kJ (205 kcal), protein 3.2 g, fat 0.7 g, carbohydrates 46.3 g, crude fibre 9.8 g, ash 3.9 g, Ca 51 mg, Mg 79 mg, P 33 mg, Fe 182 mg, Zn 0.8 mg, thiamin 0.03 mg, riboflavin 0.02 mg and niacin 1.16 mg (Wehmeyer, 1986). The seed without seed coat contains per 100 g edible portion: moisture 42.6 g, energy 950 kJ (227 kcal), protein 1.8 g, fat 0.2 g, carbohydrates (including fibre) 53.8 g, fibre 2.9 g, ash 1.6 g, Ca 32 mg, P 56 mg and Fe 4.7 mg (Leung, Busson & Jardin, 1968).
Palm wine (3.6% alcohol) contains per 100 g: moisture 98.3 g, energy 131 kJ (31 kcal), protein 0.2 g, carbohydrates 1.1 g, ash 0.4 g, Ca 0.45 mg, Mg 5.1 mg, P 1.74 mg, Fe 0.07 mg, Zn 0.02 mg, thiamin 0.01 mg, riboflavin 0.01 mg, niacin 0.50 mg and ascorbic acid 6.5 mg (Wehmeyer, 1986). Palm wine from *Phoenix reclinata* is less appreciated than that of oil palm (*Elaeis guineensis* Jacq.) in West Africa, and that of *Hyphaene coriacea* Gaertn. and *Hyphaene petersiana* Mart. in southern Africa.
Ethanolic extracts of the leaves have shown anti-cancer properties.

Adulterations and substitutes Weaving material, construction material, palm wine and edible fruits are obtained from a range of other palm species.

Description Dioecious, usually clustering, rarely solitary tree up to 15 m tall, often forming dense thickets; trunk up to 10(–12) m tall, erect or oblique, unbranched, cylindrical, up to 25(–40) cm in diameter, dull brown, the upper part with persistent leaf sheaths, the lower part free of leaf sheaths but marked with leaf scars, exuding a clear yellowish gum when injured. Leaves clustered at the end of trunk, pinnate, up to 4 m long, sheathing at the base, arching; sheath splitting and persistent, reddish-brown, fibrous; true petiole c. 15 cm long, apparent petiole c. 50 cm long, with on each side 10–15 irregularly arranged acanthophylls 3–10 cm long; leaflets up to 130 on each side of the rachis, towards the top arranged singly and regularly, towards the base in groups of 2–5,sessile, linear-lanceolate, up to 50(–60) cm × 3.5 cm, single-fold, stiff, pointed, when old splitting along the midvein, bright green, often shiny, when young bearing white indumentum on the lower surface, margin finely spiny. Inflorescence unisexual, axillary, between the leaves, branched to 1 order; prophyll 20–70 cm × 5–10 cm, 2-keeled, often persistent and splitting longitudinally into 2 halves, orange-brown at anthesis, fading to dull grey-brown; male inflorescence erect, with peduncle not greatly elongating, sometimes scarcely emerging from the bract, peduncle 10–30 cm long, greatly compressed, rachis up to 30 cm long, rachillae up to 70, arranged in groups and partial spirals, up to 20 cm long; female inflorescence erect, but arching with fruits, 30–80 cm long, emerging from the bract and often greatly elongating after anthesis, with the fruiting rachillae pendulous, peduncle up to 60 cm long, rachillae up to 40(–60), spirally arranged, up to 55 cm long, with up to 50 flowers, flowers solitary or in small groups. Flowers unisexual;



Phoenix reclinata – 1, habit; 2, part of leaf; 3, part of female inflorescence; 4, female flower; 5, male flower with one petal removed; 6, fruit.
Source: Flore analytique du Bénin

male flowers creamy white, rapidly turning brown, musty scented, calyx cup-shaped, c. 1 mm long, with 3 triangular lobes, corolla tubular at the base with 3 lobes 6–7 mm long, acute, somewhat dentate towards the apex, fleshy, stamens 6, epipetalous, shorter than petals; female flowers greenish, rounded, c. 2 mm in diameter, calyx cup-shaped, c. 1.5 mm long, with 3 triangular lobes, petals 3, free, rounded, up to 5 mm long, closely overlapping, staminodes 6, stigmas reflexed. Fruit an ovoid-ellipsoid or almost obovoid drupe 13–25 mm × 7–15 mm, pale yellow to orange or dull red, smooth, calyx and petals persistent, mesocarp 1–2 mm thick, dry or moist, 1-seeded. Seed obovoid, 10–15 mm × 5–9 mm, deeply grooved along 1 side.

Other botanical information *Phoenix* comprises c. 13 species in the Old World tropics and subtropics from the Canary Islands eastward to Hong Kong. *Phoenix reclinata* hybridizes with the true date palm (*Phoenix dactylifera*) and other *Phoenix* species.

Growth and development With adequate moisture supply *Phoenix reclinata* can reach a height of 5 m in 3–4 years. *Phoenix reclinata* forms suckers and is often found in clumps of a mother tree surrounded by smaller trees. In southern Africa flowering usually occurs in August–December, and fruits mature in February–May. *Phoenix* spp. are pleonanthic, i.e. the stems do not die after flowering. The seeds are dispersed by animals eating the fruits. These include birds, elephants, lemurs and monkeys.

Ecology *Phoenix reclinata* occurs from sea-level up to 3000 m altitude in a range of habitats, often seasonally inundated, such as on the edges of swamps, lakes and water courses in forest, woodland and wooded grassland, but also on open rocky hillsides. It sometimes forms groves. In Senegal it also occurs in thickets on the margins of salt soils. *Phoenix reclinata* prefers full sun but tolerates light shade. It also tolerates light frost. In the Okavango delta (Botswana) it is often associated with termite mounds.

Propagation and planting *Phoenix reclinata* can be propagated by seed or by suckers. The seed is separated from the fruit pulp by soaking in cold water for 3 days and changing the water every 12 hours. The 1000-seed weight is 200–1100 g. The seeds can be stored, but fresh seeds germinate best. Germination usually starts within 10 days, but may take as long as 90 days.

Management Removal of all leaves from the palm should be avoided as the tree may die. When trees are tapped for palm wine, the stem usually dies after tapping, but the clump survives. In South Africa a coppice shoot is estimated to need 6–8 years of growth before it can be tapped.

Diseases and pests *Phoenix reclinata* is slightly susceptible to lethal yellowing disease, caused by a phytoplasma.

Harvesting Palm wine may be obtained from felled or standing trees. In Côte d'Ivoire the tree is cut down, all leaves are removed and the terminal bud is cut. A cavity is made in which a brand is put in order to activate the sap flow. Collection of the sap starts 3–4 days later through a gutter linked to a calabash. Collection is done twice a day, and each time the terminal bud is further cut. Collection lasts 1–2 months. In southern Africa standing trees are tapped. A clump is first burned to remove undergrowth and leaf spines, after which selected stems are trimmed with a sharp knife to initiate sap flow. Then the stem and the bases of young leaves are cut a slight angle to guide sap into a gutter and a container. During the 5–7 weeks of tapping, the leaf bases are trimmed 2–3 times per day, until they are entirely removed.

Handling after harvest For the production of baskets in Tanzania, the individual leaflets are woven to make strips about 3–5 cm wide, which are sewn together side by side to make a mat, or coiled to make a basket.

After being tapped, palm wine is usually left to ferment for about 36 hours before it is consumed.

Genetic resources As *Phoenix reclinata* is widely distributed, occurs in a range of habitats, and readily forms suckers, the species is not threatened.

Breeding There appears to be some variability in the fruit quality, with reports ranging from soft and savoury to unpalatable, so there may be scope for selection work.

Prospects *Phoenix reclinata* is an important local source of a wide range of products, including fibre, construction material, food, fodder, palm wine, tannin and traditional medicine, and it will undoubtedly remain so in the future. Research on properties and management practices may be worthwhile, and investigations on the infraspecific variation in the quality of the fruits and other products may show prospects for selection work.

Major references Barrow, 1998; Bekele-

Tesemma, 2007; Burkill, 1997; Cunningham, 1990; Dransfield, 1986; Edwards & Egziabher, 1997; Fleuret, 1980; Kinnaird, 1992; Orwa et al., 2009; van Wyk & Gericke, 2000.

Other references Akoègninou, van der Burg & van der Maesen, 2006; Arbonnier, 2004; Aubrey, 2004; Bein et al., 1996; Cunningham & Wehmeyer, 1988; Dalibard, 1999; Dransfield & Beentje, 1995; Gautier-Béguin, 1992; Hamill et al., 2003; Leung, Busson & Jardin, 1968; Maundu et al., 2001; Neuwinger, 2000; Robinson & Johnson, 1953; Russell, 1968; SEPASAL, 2011d; Sommerlatte & Sommerlatte, 1990; Thulin, 1995a; Vanden Berghen, 1988; van Wyk & van Wyk, 1997; Wehmeyer, 1986.

Sources of illustration Akoègninou, van der Burg & van der Maesen, 2006.

Authors K. Segu

PHRAGMITES AUSTRALIS (Cav.) Trin. ex Steud.

Protologue Nomencl. Bot., ed. 2 (Steudel), 1: 143 (1840).

Family Poaceae (Gramineae)

Chromosome number $2n$ = 24, 36, 44, 46, 47, 48, 49, 50, 51, 52, 53, 54, 56, 72, 84, 96, 120. In tropical Africa $2n = 4x = 48$ predominates.

Synonyms *Phragmites communis* Trin. (1820), *Phragmites vulgaris* Crép. (1866).

Vernacular names Common reed, ditch reed, giant reed, yellow cane, reed grass, giant reedgrass (En). Roseau commun, roseau des marais (Fr). Caniço, caniço d'agua, caniço dos ribeiros, carriço (Po). Gugumua, matete, mtete (Sw).

Origin and geographic distribution *Phragmites australis* is a cosmopolitan grass that occurs on all continents except Antarctica and is thought to be the most widely distributed angiosperm. It is known in the wild, but is also cultivated and naturalized as an escape from cultivation. In tropical Africa it occurs in a belt around the dense forest zone, from Senegal east to Eritrea and from Ethiopia and Eritrea south to Mozambique, Zimbabwe, Namibia, South Africa and Swaziland. It also occurs in Madagascar.

Uses *Phragmites australis* is a multipurpose grass. The stems are used in construction for thatching and to make walls, partitions and fences, and as insulation material. They are used for plaiting baskets, mats, clothing (such as coarse aprons, hats and shoes) and cordage, to make musical instruments (flutes and whistles), arrows, light spears and fishing gear, and ear ornaments and necklaces, prayer sticks ad smoking pipes. Panicles are made into brooms and are used for decoration. The hollow stems are widely used to make rafts. Pens for writing were cut from thin sections of the stem and the stems are also used as a linear measuring device. They are useful in the manufacture of pulp for paper, cardboard, cellophane and synthetic fibres. The pulp can be processed into a fine fibrous material suitable as a filler in upholstery. The fibre is suitable for rope making. The leaves are also used for weaving mats and other objects.

Early in the growing season, young leaves and stems are a forage for cattle and horses, but later they become tough and unpalatable. The plant may be cut for hay and can provide warm-season forage, if cut during the rainy season. Animals grazing it should be fed a protein supplement. Young shoots are sometimes used as a vegetable. In North America a gum exuding from the stems is eaten. The rhizomes and seeds also serve as emergency food. In Russia the rhizomes are harvested and processed into starch. The seeds are used in rattles and as beads.

The stems are harvested for fuel where better sources are not available and *Phragmites australis* may hold promises as a second generation energy crop. A variegated form is grown as an ornamental in both private and public gardens.

Throughout the tropics and subtropics, *Phragmites australis* is used medicinally, as a remedy for arthritis, bronchitis, cancer, cholera, cough, diabetes, diarrhoea, dropsy, fever, gout, hiccup, jaundice, leukaemia, nausea, pneumonia, rheumatism, sores, stomach pains and typhoid fever. The powdered seed is used in the Western Cape area, South Africa, as an ingredient in a burn ointment and the rootstock has been used as a diaphoretic, diuretic and emetic. In Chinese medicine it is used against rhinitis and bacterial meningitis. The seed is a component of a Venda aphrodisiac.

Recently, there has been much interest in the potential of *Phragmites australis* as water-clearing plant because of its dense growth, spreading root system and its ability to absorb pollutants including plant nutrients and heavy metals. Its adaptability to alternating wet and dry conditions, makes it one of the best water-clearing plants for the tropics. *Phragmites australis* is used in many wetland rehabilitation and stabilization projects. It is used to revegetate disturbed riparian areas, control shore erosion, stabilize river and canal banks, and reduce wave action on watershed structures. In the Netherlands, for instance, *Phragmites australis* played an important role in land reclamation. In polders reclaimed from the sea, it was sown as the first crop because of its salt tolerance, while the high transpiration rate helped to dry and stabilize the soil. Afterwards the land was tilled and drained and *Phragmites australis* was eliminated.

Production and international trade Although *Phragmites australis* is widely used, few production and trade data are available. In the past, harvesting *Phragmites australis* was mainly for subsistence use, but currently a flourishing international market has emerged, for instance from the Danube delta. In Romania *Phragmites australis* production increased from about 6500 t in 1955 (all hand harvested) to 226,000 t in 1964 (89% mechanically harvested). After 1964, however, harvests decreased steadily to about 30,000 t in 1996. Other major production areas are southern Russia, Ukraine and Poland. *Phragmites australis* is shipped in raw form or as finished products to other European countries, such as Italy, Germany, and England, where the rustic look of thatched roofs and fences is popular and has become a status symbol. The commercialization of the harvesting of *Phragmites australis* by local communities in Africa has increased and trade of its products is also important. For several communities living around the Okavango delta in Botswana, harvesting reed (*Phragmites australis* and *Phragmites mauritianus* Kunth) is a major source of income. High demand, habitat decline and destructive harvesting have led to steep price increases, at least in South Africa.

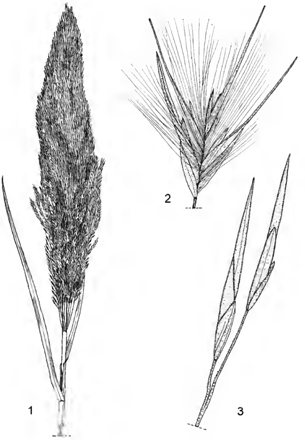
Properties Even in temperate areas, untreated stems of *Phragmites australis* deteriorate within 10 years, but with correct harvesting and preservative treatment, its life expectancy can increase about tenfold. Mature stems have greater resistance to deterioration than younger ones. In Europe well built and well maintained roofs may last 50 to 70 years, if the ridge is replaced every 5 to 15 years. The reed yield of 1.6–2 ha is needed to cover 140 m^2 roof. In Botswana the stems used for fencing last for 1.5–2 years before they deteriorate.

Mature cane is suitable for paper production. Cane harvested in the Danube delta at the beginning of winter and containing about 20% water, contains per 100 g dry matter about 43 g cellulose, 26 g lignin, 24 g pentosan. The soil type has little influence on the cellulose content; it was similar in canes growing on sandy river banks, clayey river banks, in sweet water or brackish swamps or on floating islands. The fibre is 0.8–3 mm long, 5–30.5 μm in diameter and thick-walled. Fibre cells are accompanied by abundant thin-walled pitted fibres of variable lengths.

Leafy material is suitable as fodder, especially when young. Older stems are less palatable. During the growing season the carbohydrate content falls from about 50 g to about 10 g per 100 g dry matter, mainly in favour of the cellulose content which rises from 16 g to 44 g per 100 g dry matter. Analysis of young leafy samples from the Danube delta indicated 31% dry matter, containing per 100 g: 40–45 g N-free extract, about 1.8 g crude fat, 31–35 g crude fibre, 14 g crude protein, and 11 g ash. Hay (dry matter 86%) contained per 100 g dry matter: fat 0.5 g, sugars/starch 20 g, cellulose 12 g and digestible protein 3 g. The relatively high silica content reduces the palatability. It is lower in cane grown on floating islands and in acidified dried cane.

Adulterations and substitutes As a source of thatching material *Phragmites australis* is often replaced by other grass species including *Hyparrhenia hirta* (L.) Stapf (common thatching grass) and *Hyperthelia dissoluta* (Nees ex Steud.) Clayton (yellow thatching grass), or by palm leaves.

Description Robust, perennial grass arising from an extensive, stout, vertical and horizontal creeping rhizome; stem (culm) straight, up to 6 m tall and 15 mm in diameter, leafy throughout, nodes glabrous, internodes 10–25 cm long, hollow, usually farinose below nodes; above-ground stolons often present. Leaves alternate, simple and entire; sheaths imbricate at first, later shorter than the internodes, loose, smooth, ligule a rim of hairs 1–1.5 mm long; blade usually drooping, linear to very narrowly lanceolate, up to 100 cm × 0.5–5 cm, base slightly auriculate, apex filiform acuminate, rather firm, glabrous but sometimes pilose near the base and sometimes scaberulous along the edges. Inflorescence a plumose, strongly branched panicle oblong to ovate-oblong in outline, up to 50 cm × c. 10(–17) cm, erect, later nodding, silvery-purplish or brownish, with silky beards at lowest branches; rachis terete in the lower part, angular in the upper part, barbate at the nodes; branches fascicled, angular, some of them bearing spikelets almost to



Phragmites australis – 1, inflorescence; 2, part of inflorescence; 3, spikelet.
Redrawn and adapted by C.Z. Gbéhou (Flore analytique du Bénin)

their base, densely hirsute at insertion. Spikelets cuneate, laterally compressed, 10–18 mm long, on glabrous or pilose pedicel 2–4 mm long, with (3–)4–8(–10) florets at base; lowest 1–2 flowers male; following flowers bisexual; apical flower reduced; glumes 2, acute, 3- or 5-veined, persistent, lower glume 3–5 mm long, upper glume 6–9 mm long; lower lemma linear-lanceolate to linear-oblong, 8–15 mm, acute to acuminate, with the margins involute; fertile lemmas 9–12 mm long, narrowly lanceolate, acuminate, glabrous; lodicules 2, 1–1.5 mm long, plumose with hairs 6–10 mm long and as long as lemma; palea 1.5–4 mm long; stamens 1–3 in basal florets, 3 in apical florets, anthers c. 4 mm long; ovary with bifid, hairy style. Fruit a caryopsis (grain) c. 1–5 mm long, bristled.

Other botanical information *Phragmites* is a cosmopolitan genus of at least 4 species, of which 3 occur in tropical Africa. The species of the genus are very close and difficult to distinguish. *Phragmites mauritianus* Kunth differs from *Phragmites australis* in having woodier stems, more rigid leaves and smaller glumes. *Phragmites karka* (Retz.) Trin. ex Steud. is intermediate between *Phragmites australis* and *Phragmites mauritianus* in many morphological characters. Introgression, occurring where the distributions overlap, has blurred the distinctions still more.

Phragmites australis is extremely polymorph, with numerous ecotypes and chromosomal variants (both polyploidy and aneuploidy playing a role). Two subspecies are recognized: *Phragmites australis* subsp. *australis*, widespread in temperate regions of both hemispheres, and *Phragmites australis* subsp. *altissimus* (Benth.) Clayton, from the shores of the Mediterranean, extending to Iran, and southwards to Arabia, Ethiopia, Kenya and the southern edge of the Sahara. The 2 subspecies are rather imperfectly distinguished by the shape of the upper glume.

Growth and development *Phragmites australis* flowers and fruits throughout the year in frost-free areas. Pollen fertility and seed set are poor as abnormalities often occur during mitosis. Self-incompatibility or at least partial self-incompatibility is common. While self-pollination yielded 2.8 and 8.9% seed set in two Japanese populations, cross-pollination produced 52.4 and 64.4% seed set. Consequently, accretion from seed is generally low, but may be important in the spread to new sites. Germination only occurs in shallow water. If conditions are favourable, germination may begin within 2 days at 25–27°C, or after 4–5 days at 15–16°C. Germination rates decrease with increasing salinity; a concentration of 50 mmol NaCl decreased germination. Germination is a highly vulnerable period and optimum habitat conditions for germination differ from the typical environment of the adult plant.

Vegetative propagation through dispersal of rhizome fragments by water currents, animals and humans is an important means of colonization of new areas. Once established, expansion of a stand occurs primarily through vegetative growth of the rhizome.

Approximately two thirds of the biomass is allocated to the rhizome, which can reach a depth of 2 m. This growth pattern produces homogeneous clumps with up to 200 stems/m². Throughout most of its range *Phragmites australis* typically forms closed mono-dominant stands in both disturbed and pristine areas, even though its own litter reduces its growth. In Europe, lateral rhizome spread has been as great as 1–2 m per year, and during periods of decreasing water levels, colonies can increase in width by as much as 15 m in a single season. Stolons, which may grow up to 11 cm per day, are produced in young stands or over open water; they further aid in rapid stand expansion.

Stems are renewed each growing season. Growth can reach 4 cm/day. Rhizomes of *Phragmites australis* live for 3 to 7 years, horizontal parts up to 12 years. Rhizomes contain an extensive horizontal and vertical aeration system allowing rapid metabolism. Buds develop at the base of the vertical rhizomes in late summer each year. These buds mature and typically grow about 1 metre (up to 10 m in newly colonized, nutrient-rich areas) horizontally before terminating in an upward apex and going dormant until spring. The apex then grows upward into a vertical rhizome, which in turn produces buds that will form more vertical rhizomes. Vertical rhizomes also produce horizontal rhizome buds, completing the vegetative cycle. The aerial shoots arising from the rhizomes are most vigorous at the periphery of a stand. While morphology is not directly based on ploidy level, it has been found that giant reeds are most often octoploid and fine reeds are either tetraploid or hexaploid. In Romania octoploid plants have greater vegetative vigour and grow in deeper water than tetraploids and are sometimes found in floating reed-beds, while tetraploids are more common in shallow water and in more saline habitats.

Phragmites australis is a C_3 plant, but has anatomical characteristics intermediate between C_3 and C_4 plants.

Ecology *Phragmites australis* is best adapted to marshes and shallow water along the shoreline of lakes, ponds, swamps, ditches, streams, canals, rivers, and estuaries. It grows best where the water level fluctuates from 15 cm below soil surface to 15 cm above. Growth rates are higher in shallow (5–20 cm) than in deep (70–75 cm) water, but depth may reach 1 m. Wind generated waves may amplify the negative effects of high water depth. Minor water movement promotes the creation of floating mats or islands in which reed growth continues without soil contact.

Although *Phragmites australis* grows best on clay, it occurs in a wide variety of soils and tolerates moderate salinity. Stands in the Nile Delta tolerate a soil pH of 7.0–9.3. Low nitrogen or phosphorous availability, high salinity and extensive tidal flooding may limit growth. Standing dead material often totals twice as much biomass as current growth, allowing stands to burn even during the growing season. *Phragmites australis* tolerates fire if water is above the soil surface. It also tolerates late season drought; deep rooting imparting drought resistance. *Phragmites australis* is a warm-season grass that starts growth after the last frost has occurred and remains green until frost in autumn. Wide climatic tolerance is indicated by its range that stretches from the tropics to cold temperate areas and from sea level to elevations of at least 2000 m, reaching 3000 m in Tibet.

Phragmites australis is often found in association with other wetland plants including species of *Carex*, *Cyperus*, *Nymphaea*, *Typha*, *Juncus*, *Myrica*, and *Phalaris*. Emergent shoots of *Phragmites australis* compete successfully with these species.

Phragmites australis is a serious weed in many areas and is considered a noxious weed in the United States. It is a weed of rice in Senegal, cotton, maize, and rice in Russia, sugar beet in Zimbabwe and the Netherlands, and sugarcane in Australia. Once established, it is difficult to eradicate, and it can block canals, streams, and drainage ditches. It is common on irrigated land, where it infests all crops. *Phragmites australis* aggressively colonizes large areas of shoreline and shallow marshes; its thick sod and heavy stand of stems effectively prevents wave- and current-caused erosion, but the single-species stands may completely displace other native marsh communities and many of the fauna they support.

Propagation and planting *Phragmites australis* may produce large quantities of seed, but often very few are viable. Water depths of more than 5 cm and salinities above 2% by weight prevent germination. The germination is not affected by salinities below 1%. The germination percentage increases with increasing temperature from 16 to 25°C, while the time required to germinate decreases from 25 to 10 days over the same temperature range. Once established, *Phragmites australis* spreads by rhizomes and stolons. Small parts of rhizomes take root easily; therefore, tillage promotes vegetative reproduction. New stands are sometimes established by planting rhizome segments. This is normally not recommended because of the invasive nature of the species.

It is possible to produce young plants of *Phragmites australis* through in-vitro culture of immature inflorescences. A micropropagation system has been developed using 2,4-D to initiate callus growth and myoinositol to induce somatic embryogenesis.

Management *Phragmites australis* cannot withstand prolonged heavy grazing. Its upright growth makes it easy for livestock to remove all the leaves. For maximum production, no more than 50% of current year's growth by weight should be grazed off.

The effects of nutrients on the growth of *Phragmites australis* is complex. Biomass, density, shoot length and diameter were reported to be higher from constructed wetlands flooded with sewage sludge than from natural sites. Positive relationships were also detected between the nutrient supply and stalk and rhizome growth, above ground and below ground biomass, and the ratio of above ground to below ground biomass. On the other hand, it has been found that increasing amounts of nitrogen (caused by intensive agriculture and eutrophication, for instance) result in reduced amounts of sclerenchyma in both shoots and rhizomes and, consequently, in reduced strength of the plants. Others found that nutrient levels usually have no significant effect on stem morphology.

Although the accumulation of heavy metals in *Phragmites australis* is well investigated, their effects on reed growth and morphology are less studied. There are reports confirming that copper may reduce the length and dry weight of roots and shoots and that accumulated heavy metals cause reduced reed growth especially under flooded conditions.

Eliminating weedy stands is difficult. The best approaches are heavy grazing by cattle, and repeated spraying with a herbicide, e.g. glyphosate. Combining herbicide and grazing or mowing gives the best results. Burning in spring also effectively kills a significant proportion of plants.

For waste-water treatment, polluted effluent is routed through a septic tank-like compartment, where the solid waste is allowed to settle. The water then trickles through a constructed wetland or artificial *Phragmites australis* bed, where bacterial action on the surface of roots and leaf litter breaks down organic waste and removes many of the pollutants. The water is then suitable for irrigation or discharge to natural watercourses. A disadvantage of such systems is that most of the pollutants are stored in subsurface biomass, making removal difficult without some destruction of shoot, rhizome and root structures.

Diseases and pests Few diseases and pests of *Phragmites australis* have been recorded in tropical Africa; *Puccinia coronata* (crown rust) is recorded in East Africa, and *Saccharicoccus sacchari* (grey sugarcane mealybug) and *Dimorphopterus* (a seed bug) throughout tropical Africa. Worldwide many diseases and pests of *Phragmites australis* have been recorded, but none of them is reported to have caused major damage.

Harvesting *Phragmites australis* stems of the desired quality are selected and harvested by using knives, machetes and sickles or mechanized harvesters. Harvesting is best done when seed has matured and when fine leaves have started to dry. Moisture content should also be as low as possible to minimize insect and fungal attacks. To take advantage of the most durable part of the stem, it should be cut as close to the ground as possible. The stems with cut ends aligned, are loosely tied in small bundles and combed to remove debris and fine leaves. The straight hollow stems are cut in late autumn or winter and dried. In general, harvesting increases reed density, but also increases the amount of dead rhizomes while it decreases growth rate and shoot length and diameter. As a result of over-harvesting, many *Phragmites australis* beds in communal areas in southern Africa have been degraded and are no longer producing stems of the desired quality. Harvesters in the Tembe Elephant Park, South Africa do not select *Phragmites australis* of only a particular thickness and height to harvest. Usually an area is selected and all *Phragmites australis* within that area are harvested. The cut reed is sorted into bundles containing stems of even thickness and length. The taller and thicker stems are the most prized and of the highest quality.

Yield No data on fibre yield in Africa are available, but 1.6–2 ha is needed to cover 140 m^2 roof.

Handling after harvest Freshly cut stems, complete with leaves are tied into bundles and left standing for a few days, allowing the leaves to transpire and reduce the starch content of the stem. This method, called 'clump curing', reduces attack by borer beetles, but has no effect on termites or fungi. Effective resistance to termites, most types of fungus and fire is achieved mainly by chemical treatment. Dry, well ventilated storage is essential.

The technology of making pulp from reed on an industrial scale has been known since the beginning of the 20th century, and it has been considered, abandoned and re-considered several times. The main problem was the preparation of the raw material (harvesting, transportation, storage, removal of leaves, knots and tops, etc.). Alkaline pulping processes have appeared most favourable. *Phragmites australis* pulp is suitable as a blend with other pulps for writing and printing papers. In China most *Phragmites australis* pulp is made by the bisulphite process. Parenchyma and epidermal cells are removed by screening in order to improve workability and paper properties.

Genetic resources As *Phragmites australis* is distributed widely in the tropics and subtropics, there is no risk of genetic erosion and also because a great deal of genetic diversity is being maintained in managed stands. A study in Italy found old monoclonal stands in stable environments, but also greater variability in younger stands in more dynamic environments. Genetic differences between populations in northern Italy and eastern Romania were small, indicating exchange of genetic material over large distances. *Phragmites australis* germplasm collection is maintained by the Institute of Crop Science (CAAS) and N.I. Vavilov All-Russian Scientific Research Institute of Plant Industry, St. Petersburg, Russian Federation.

Breeding Very little selection or breeding work on *Phragmites australis* has been done.

Prospects *Phragmites australis* is of great economic importance because of its many uses and its adaptability to a wide range of ecological conditions, including degraded sites. Special consideration should be given to using *Phragmites australis* for soil rehabilitation in local land-use systems. Future efforts should focus on the expansion of product research and development, the development of harvesting and processing equipment, and the identification of more efficient crop management strategies. The taxonomy of *Phragmites* and the distribution of its species also need research attention.

Major references Clayton, 1970a; Clevering & Lissner, 1999; Engloner, 2009; Gibbs Russell et al., 1990; Gordon-Gray & Ward, 1971; Lambertini et al., 2006; Lambertini et al., 2008; Launert, 1971; Mal & Narine, 2004; Russell & Kraaij, 2008.

Other references Bonnie, Hanganu & Griffin, 1997; Burkill, 1994; Clevering, 1998; Daniels, 1991; Duke, 1998; Ekstam & Forseby, 1999; Fér & Hroudová, 2009; Ilvessalo-Pfäffli, 1995; Katsenovich et al., 2009; Lauzer, Dallaire & Vincent, 2000; Marks & Randall, 1994; McKee & Richards, 1996; Mmopelwa, 2006; Peters, 1994; Quattrocchi, 2006; Rodewald-Rudescu, 1974; Tewksbury et al., 2002; Tyler-Walters, 2002; Uchytil, 1992b; Van Rooyen et al., 2004.

Sources of illustration van der Zon, 1992.

Authors A. Maroyi & L.P.A. Oyen

PHRAGMITES KARKA (Retz.) Trin. ex Steud.

Protologue Nomencl. Bot., ed. 2 (Steudel), 2: 324 (1841).

Family Poaceae (Gramineae)

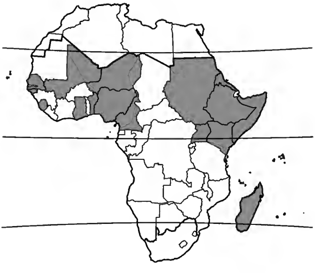
Chromosome number $2n$ = 18, 24, 36, 38, 48

Synonyms *Arundo karka* Retz. (1786), *Phragmites vallatoria* (Pluk. ex L.) Veldkamp (1992).

Vernacular names Reed, tropical reed, flute reed, nodding reed (En). Roseau (Fr). Caniço (Po).

Origin and geographic distribution *Phragmites karka* is distributed from Africa through India and South-East Asia to Australia and Oceania. In tropical Africa it occurs from Senegal east to Eritrea and south to Kenya and Uganda; it is also reported from Madagascar.

Uses The stems of *Phragmites karka* are used for the same purposes as those of the more common *Phragmites australis* (Cav.) Trin. ex Steud.: for thatching, construction of walls, partitions and fences, and wickerwork for a great variety of purposes, such as mats, baskets, hats, fans, bags and purses. In northern Ghana, for instance, the Bolga baskets of commerce are made from twines plaited with split stems of *Phragmites karka*. Stems with panicles serve as brooms. The best brooms are made of stems with very young panicles. The



Phragmites karka – wild

stems have been used in water-pipes and to make arrow shafts. In Uganda bird-traps are made from the stems. In Ghana the hollow stems are used for flutes, pipes and whistles, and in Nigeria the stems are used to make mouth-pieces for flutes. In India the stems are a source of pulp for paper making. It is also suitable to make fair-quality board and the chemical solvent furfural.

In Africa and Asia young shoots are eaten, mainly in times of famine. Young shoots also make good fodder. *Phragmites karka* can be used for soil stabilization, especially along shores of lakes and streams. It is planted in basins and constructed wetlands to treat mainly domestic waste water, but also waste water from industrial sources. Dry stems are used as fuel when better material is not available. Leaves are used as fertilizer for ponds. Variegated forms are planted as ornamental.

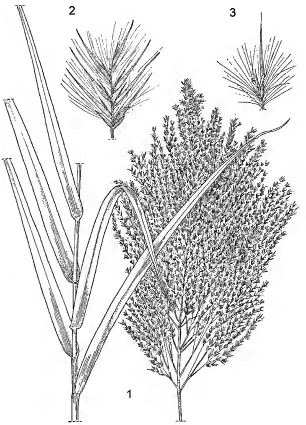
In traditional medicine in India, the roots are used to heal broken bones, and the whole plant is used against rheumatic pain. The rhizomes and roots are anti-emetic and diaphoretic and are used for the treatment of diabetes.

Production and international trade Although *Phragmites karka* is widely used, no information is available on production and trade.

Properties Oven-dry reed (stem with inflorescences) of *Phragmites karka* contains about 55% cellulose (Cross and Bevan method), 23% pentosans, 26% lignin and 3% ash. Pulps suitable for writing and printing paper can be obtained from the reed with the soda or sulphate process, with a bleached pulp yield of about 40%. The fibres in the pulp are (0.5–)1.2(–3.2) mm long and (6.6–)11.6(–19.8) μm wide. Because of the shortness of the fibres *Phragmites karka* pulps have to be mixed with long-fibre pulps to be used in commercial paper machines.

Several projects in Asia have shown that constructed wetlands with *Phragmites karka* as one of the component plant species, are very efficient in treating household sewage under tropical conditions and can also remove plant nutrients and heavy metals. In India a constructed wetland with *Phragmites karka* planted in the last cell and treating conventionally treated distillery effluent, about 50% of the remaining organic matter and nitrogen were removed and 80% of the remaining phosphate.

Description Robust, erect, strongly tufted, perennial grass with an extensive, creeping, branching rhizome or stolons up to 20 m long; stem (culm) 2–8 m tall and 1.5 cm in diameter, very stout, often woody with hollow internodes and glabrous nodes. Leaves alternate and simple; sheaths longer than the internodes, imbricate and tight at first, later slipping off the stem, dorsally rounded, striate, glabrous or pilose near the mouth; ligule c. 1 mm long, fringed with hairs; blade linear, 20–80 cm × 1–4 cm, base broadened, margin smooth or rough, apex stiff and tapering-acute, glabrous above, scabrid beneath towards the apex, usually with 2–3 shallow depressions. Inflorescence a loose panicle 20–75 cm long with a rather robust central axis and repeatedly branched, thin, rough, erect or nodding branches which are crowded in groups. Spikelets 10–12 mm long, on pedicel 2–10 mm long, 3–7-flowered, rachilla with numerous, thin, white-silvery hairs 4–8 mm long; lowermost floret sterile or male and persistent, succeeding florets bisexual and disarticulating below each fertile floret; glumes boat-shaped, ovate-lanceolate, 3–4.5 mm long, 3(–5)-veined, acute, awnless, upper glume larger than lower one; lemma narrowly elliptical, 7–12 mm long; palea 2.5–3 mm long, scabrid on the veins; stamens 2 or 3; pistil with



Phragmites karka – 1, habit of leafy culm and inflorescence; 2, spikelet; 3, floret.
Source: PROSEA

stipitate ovary, 2 styles with plumose stigmas exserted laterally near the base of the spikelet. Fruit a caryopsis (grain), crowned by the stylar base.

Other botanical information *Phragmites* is a cosmopolitan genus of about 4 species, of which 3 occur in tropical Africa. The species are very similar, distinguishing characters overlap and combinations of characters are needed to distinguish the species. The genus is sometimes considered monospecific. Differences between *Phragmites karka* and *Phragmites mauritianus* Kunth are sometimes considered too small to consider them separate species; in the Flora of Ethiopia, for instance, all specimens earlier identified as *Phragmites mauritianus* are included in *Phragmites karka*. Genetic analysis, however, shows the 4 species as separate groups.

Growth and development The leaves of *Phragmites karka* have movable sheaths so that all leaves turn leeward in the wind. In a natural stand in Rajasthan (India) the standing above-ground dry biomass was measured at 4.2–6.7 kg/m^2, and the underground biomass 0.8–1.2 kg/m^2; in a transplanted stand, the above-ground dry biomass was 16.7 kg/m^2.

Ecology *Phragmites karka* occurs in tropical and subtropical regions in fresh-water and brackish marshy or seasonally flooded soils and moist locations, such as river banks and lake shores. It grows in standing and flowing water, usually in clay soils ranging from strongly acid to slightly alkaline. Fulani people in West Africa consider its presence an indication of fertile soil. In shallow waters *Phragmites karka* can form extensive masses of vegetation which are important feeding and breeding grounds for fish. Tree seeds from the surrounding forest may germinate in these reed masses leading to progressive expansion of the forest into the wetland. *Phragmites karka* may become a weed in irrigation systems and rice fields.

Propagation and planting *Phragmites karka* spreads naturally and can be propagated by division and by seed. A procedure has been developed for the large scale micropropagation of *Phragmites karka* from axillary buds, with buds from the lower and middle stem giving best results. Multiple shoot formation and root initiation occurred on Murashige and Skoog basal medium supplemented with 0.5 mg/l benzyladenine (BA), 0.5 mg/l kinetin and 2% sucrose.

Management *Phragmites karka* tolerates some grazing, but under heavy grazing it is replaced by less palatable species. As a weed it can be controlled by heavy grazing or draining and burning. Burning is tolerated when plants are flooded.

Yield No information is available on the yield of *Phragmites karka* in tropical Africa. A uniform stand of *Phragmites karka* in a constructed wetland system for waste-water treatment in central India produced about 12 kg/m^2 dry biomass within 1 year, of which about 11 kg/m^2 was aboveground.

Handling after harvest Before stems are used as thatch, remaining parts of leaves are removed. The stems may be split before being used for thatching. In Java, Indonesia the stems are sometimes flattened with a hammer, halved, dried and scraped before being used for very coarse wickerwork. Brooms are made by tightly binding the stems to a central piece of bamboo or wood about 2 cm in diameter, with the panicles arranged in a fan-like manner.

Genetic resources *Phragmites karka* is widespread and dominant in parts of its habitat; it is not endangered by genetic erosion. A few accessions of *Phragmites karka* are included in germplasm collections of sugarcane in India.

Breeding No selection or breeding programmes are known.

Prospects *Phragmites karka* and related *Phragmites* species will probably remain a source of thatch and material for wickerwork; where large stands occur, commercial harvesting may become more important. It is likely that it will also become more important in the biological treatment of sewage and industrial effluents and the stabilization of stream banks and lakeshores. The taxonomy of *Phragmites* and the distribution of its species also need research attention.

Major references Akoègninou, van der Burg & van der Maesen, 2006; Burkill, 1994; Clayton, Harman & Williamson, 2006–; Clayton & Renvoize, 1982; Clevering & Lissner, 1999; Innes, 1977; Lambertini et al., 2006; Oyen, 2003; Phillips, 1995; van der Zon, 1992.

Other references Abbiw, 1990; Bhat & Virmani, 1952; Billore et al., 2001; CAB International, 2007; Cheng et al., 2008; CIAT/FAO, 2002–; CSIR, 1969; Gilliland, 1971; Kakudidi, 2004; Kushwaha, Sharma & Gopal, 1991; Palaniappan, 1974; Poonawala, Jana & Nadgauda, 1999; Rotkittikhun et al., 2006; Singh & Srivastava, 2007.

Sources of illustration Oyen, 2003.

Authors L.P.A. Oyen

Based on PROSEA 17: Fibre plants.

PHRAGMITES MAURITIANUS Kunth

Protologue Révis. Gramin. 1: 227, t. 50 (1830).

Family Poaceae (Gramineae)

Chromosome number $2n = 48, 79, 80, 81$

Synonyms *Phragmites communis* Trin. var. *mauritianus* (Kunth) Baker (1877), *Phragmites pungens* Hack. (1901).

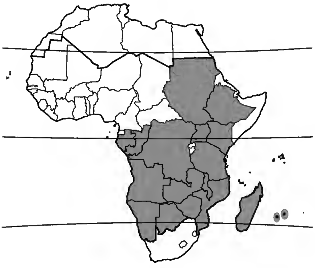
Vernacular names Reed grass, lowveld reed, spear reed (En). Roseau, roseau à feuilles piquantes (Fr). Caniço (Po). Gugumua, mtete (Sw).

Origin and geographic distribution *Phragmites mauritianus* is distributed in Central, East and southern Africa, with a northern limit through Ethiopia, Sudan, DR Congo, Congo and Gabon, and in Madagascar and the Mascarene islands. It is also recorded along the Nile in Sudan and Egypt.

Uses The stems of *Phragmites mauritianus* are used for thatch and to make walls and partitions in houses, fences, and as insulation material. They are also split and used for plaiting and wickerwork in a similar way as those of *Phragmites australis* (Cav.) Trin. ex Steud., for instance for mats and fish traps. The hollow stems are used as drinking straws.

Young growth is grazed by domestic and wild animals. The rhizomes are eaten, especially in times of famine. *Phragmites mauritianus* can be used for soil stabilization, especially along shores of lakes and streams. It is planted in basins and constructed wetlands to treat mainly domestic waste water, but also waste water from industrial sources. Dry stems are used as fuel when better material is not available.

A decoction of the aerial parts is drunk for the treatment of malaria. Eyes are sprinkled or bathed with leaf sap against conjunctivitis. In Zimbabwe the sharp edges of leaves are rubbed on affected areas to treat sexually transmitted diseases. Pieces of reed are used to insert enemas. The pounded rhizome mixed with salt is used on painful body parts to treat pneumonia. In Tanzania *Phragmites mauritianus* is used to treat thrush in infants and burns, in South Africa it is used to treat barrenness in women. In Uganda it is used in veterinary medicine for treating retained placenta.



Phragmites mauritianus – wild

Production and international trade For several communities living around the Okavanga delta in Botswana harvesting reed (*Phragmites mauritianus* and *Phragmites australis*) is a major source of income. High demand and destructive harvesting have led to steep price increases, at least in South Africa.

Properties *Phragmites mauritianus* is used for similar purposes as *Phragmites australis*, but details of its properties have not been published.

Botany A robust perennial grass with very long creeping rhizomes and stolons, sometimes floating; stem (culm) (2–)4–8 m tall, up to 4 cm in diameter near the base, 3–9 mm beneath the panicle, many-noded, terete, erect, simple or more rarely branched, glabrous, smooth. Leaves alternate, simple and entire; sheaths longer than the internodes, imbricate and tight at first, later slipping off the stem, dorsally rounded, striate, glabrous or pilose near the mouth; ligule c. 1 mm long, fringed with hairs; blade linear-lanceolate, 15–100 cm × 1–4 cm but often rather short in sterile shoots, expanded or convolute, slightly auriculate at the base, tapering to a fine, pungent apex, rather rigid, glabrous or pilose near the base, scaberulous on both surfaces or at least on the lower, very rarely smooth, scabrous along the edges. Inflorescence an open panicle 15–60 cm × 8–20 cm, rarely larger, usually rather dense, green or tinged with purple, slightly silvery, yellowish or brown at maturity; branches usually bare of spikelets for some distance from the base. Spikelets cuneate, laterally compressed, 7–16 mm long, on filiform pedicel up to 10(–12) mm long, comprising 1 basal sterile floret, 3–11 fertile florets, and reduced florets at the apex; glumes ovate to ovate-oblong, rarely oblong, acute at apex, lower glume 2–4(–6) mm long, upper one 3–5(–6) mm long; lower lemma lanceolate-oblong to oblong, 6–8(–10) mm long, 3-(rarely 5–7)-veined; the following one fertile, narrowly lanceolate, 6–11 mm long, 1–3-

veined, callus 0.5–1 mm long with hairs 5–7 mm long; palea 2–6 mm long; anthers 3 (2 in sterile floret), c. 2 mm long; ovary glabrous, with 2 stigmas. Fruit a caryopsis (grain) with elliptical hilum.

Phragmites is a cosmopolitan genus of about 4 species, of which 3 occur in tropical Africa. The species are very similar, distinguishing characters overlap and combinations of characters are needed to distinguish the species. The genus is sometimes considered monospecific. *Phragmites mauritianus* is most closely related to *Phragmites frutescens* H.Scholz from the eastern Mediterranean. The latter may represents a group of isolated, perhaps relictual, populations of *Phragmites mauritianus*. Clones of *Phragmites australis* from the Gulf Coast of the United States show close resemblance to *Phragmites mauritianus* in leaf characteristics.

Phragmites mauritianus is vigorous and fast growing. In undisturbed places in Lake Victoria accumulated dry phytomass reached 64 t/ha, of which about 70% above-ground and 30% below-ground. The growth rate after cutting was about 30 t/ha of dry matter in a period of 4 months.

Ecology *Phragmites mauritianus* is common along rivers, lakes and dams and in swamps, floodplains and vleis, often growing partially submerged. It occurs at altitudes of 580–1500 m.

Stands along rivers are very dynamic. Observations in Kruger National Park in Mpumalanga, South Africa indicated that propagation by seed must play an important role in the establishment of new colonies, especially when reeds colonize the previously un-vegetated edges of new active channels. These new patches would then expand by clonal growth. Destruction of reed patches by flooding, wave action, herbivores or prolonged drought contribute to the dynamics of the vegetation.

Management In the Okavanga delta in Botswana *Phragmites mauritianus* is preferred to *Phragmites australis* for harvesting. It is more common than the latter, taller and more productive. In Hluhluwe-Umfolozi Park, South Africa, harvesting the reedbeds in Fuyeni causes a decrease in average reed size through the removal of large reeds: in uncut areas 66% of the total reed density consists of large reeds, in cut areas only 15%. Reed regeneration after cutting is rapid, but the proportion of large reeds remains low. Harvest of no more than 30% of the large reeds is recommended and a given area should not be harvested more frequently than biennially to allow young shoots to mature into large, usable reeds.

Phragmites mauritianus is often grown in natural or constructed water-clearing wetlands. In swamps bordering Lake Victoria, sludge effluent from water treatment plants had little negative effect on the productivity of *Phragmites mauritianus*. It seems less suitable to clear paper-mill effluents, because they contain compounds that are not easily biodegradable.

Genetic resources and breeding *Phragmites mauritianus* is widespread and locally dominant. It is not in danger of genetic erosion except where it is heavily harvested or grazed. *Phragmites mauritianus* is not represented in germplasm collections and no breeding or selection work is known.

Prospects *Phragmites mauritianus* will remain an important source of thatch and construction material. Its role in water clearing is likely to increase and deserves more research attention. The taxonomy of *Phragmites* and the distribution of its species also need research attention.

Major references Clayton & Renvoize, 1982; Clayton, Harman & Williamson, 2006–; Fanshawe, 1972; Kaseva, 2004; Lambertini et al., 2008.

Other references Abira, Ngirigacha & van Bruggen, 2003; Bingham, 1990; Gelfand et al., 1985; Kambizi & Afolayan, 2001; Koechlin, 1962; Kotschy & Rogers, 2008; Launert, 1971; McKean, 2001; Mugisha et al., 2007; Neuwinger, 2000; Okurut, Rijs & van Bruggen, 1999.

Authors L.P.A. Oyen

PILIOSTIGMA RETICULATUM (DC.) Hochst.

Protologue Flora 29: 599 (1846).

Family Caesalpiniaceae (Leguminosae - Caesalpinioideae)

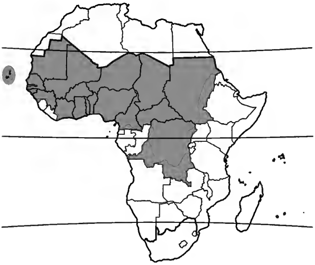
Chromosome number $2n = 28$

Synonyms *Bauhinia reticulata* DC. (1825).

Vernacular names Camel's foot (En). Pied de chameau, semellier (Fr). Musacanca (Po).

Origin and geographic distribution *Piliostigma reticulatum* occurs in the Sahelo-Sudanian region from Senegal and Mauritania eastward to Sudan. It has been introduced into Mozambique.

Uses The fibrous bark is used for tying. In Burkina Faso and Niger, for instance, the bark is used for tying roof rafters of granaries, huts or houses, and it is used in the production of articles such as baskets, chairs, mats, arrows



Piliostigma reticulatum – wild

and masks. In Senegal Serer fishermen make nets from the bark. In northern Benin farmers use the bark to tie firewood gathered in the bush or to tie up sheep and pigs to houses during the rainy season. In Sudan it is made into cloth. The bark and resin from the bark are used for fastening the metal parts of tools and weapons to the handles. The leaves are used to wrap foods. The stems are used as toothbrushes.

The tree provides poles and the wood is used for making tool handles, household utensils, stools, masks and other small articles. It is also used as tinder, as fuelwood and for making charcoal. The use of the bark for house building and as fuel is reported in south-western Niger.

In Burkina Faso the young leaves, fruits and roots are cooked and eaten. The boiled leaves are added to cereal porridge to make it more acid and keep it edible for several days. The young fruits are eaten as a vegetable, and the seeds as a condiment or as food in times of scarcity. The pounded and boiled fruits are made into drinks. The leaves, branches, pods and seeds are eaten by cattle, sheep, goats and camels.

The roots yield a red dye, the fruits and seeds a blue one. The bark is used for tanning hides and chewed to stain the teeth red. Young leaves are used for coagulating rubber. In Burkina Faso a leaf decoction is used for making the skins of drums supple. The fruits are burnt for smoking beehives to make these attractive to bees. In Nigeria the fruits are burnt as fuel or used for strengthening uncured clay pots. A perfume is made from the seeds. In Nigeria the seeds are sometimes chewed as a substitute of kola nuts or to stain the lips red. In central Burkina Faso, the plant is considered to contribute to soil improvement and farmers use the leaves for mulching. In addition *Piliostigma reticulatum* provides shade during agricultural activities, e.g. in nurseries.

The species is extensively used in traditional medicine. The roots are used for the treatment of gonorrhoea, hookworm, ascites and dropsy. Root infusions are taken against diarrhoea and uterine pain. Root decoctions are used in preparations against liver and gall complaints, and are drunk as an antidote for plant poison. Root decoctions or macerations are taken or used in vapour baths against cough, diarrhoea, constipation, stomach-ache and muscular pain. The sap of ground roots is applied on swellings in dislocations, and taken against painful pregnancy and nausea.

The bark is widely used on wounds, cuts, ulcers and sores as an astringent, haemostatic, antiseptic and cicatrisant. Bark decoctions are used for washing wounds and as a mouthwash, and for the treatment of fever, colds, stomach-ache, indigestion and diarrhoea. A decoction of the bark boiled in milk or bouillon is drunk against gonorrhoea. Bark infusions are taken against toothache and vomiting. The bark is chewed against cough, or a bark maceration is drunk. A maceration of the inner bark is used as a wash against ringworm. The fresh bark is attached to body parts that are swollen due to inflammation. In Gabon the bark is used to immobilise fractures. In Niger the aerial parts are used as a tonic for women who have given birth and they form part of preparations against fever in children. Boiled young shoots are chewed by children with toothache.

The leaves are used against fever and as a tranquillizer, and for the treatment of a range of ailments including colds, bronchitis, headache, rheumatism, ophthalmia, toothache, mumps, syphilis, vertigo and epilepsy. Leaf preparations are often applied on wounds, ulcers and sores; they are considered haemostatic, antiseptic and cicatrisant. Ground fresh leaves are applied in case of inflammation. Young leaves are eaten raw against nausea. Boiled leaves are rubbed in against lumbago. In northern Senegal a decoction of the leaves in a vapour-bath is used against conjunctivitis. Leaf decoctions are taken by women in labour to ease delivery, and are used in draught and in baths as a sedative and against epilepsy and possession. Leaf decoctions are also taken against dysentery, haemorrhoids, malaria and hernia. In Nigeria leaf decoctions are used to foment fractures and to get rid of guinea worm. A leaf decoction is rubbed into scarifications for the treatment of leg pain. Leaf infusions are used in drinks or baths as a sedative and anti-rachitic for new-born children, and to stimulate their appetite. Macerations of young leaves and flower buds are given against rickets in babies, kwashiorkor and anorexia.

The fruit is used as a laxative and for the treatment of wounds, sores, ringworm, headache, encephalitis, bronchitis, cough, liver problems and indigestion. In Burkina Faso crushed or powdered fruits are applied on the skin for the treatment of wounds and skin problems, and burnt and crushed fruits against cough. In Senegal the powdered fruit in water is taken by draught or used topically in case of snake bites.

In traditional veterinary medicine the powdered root is put into drinking-water for the treatment of diarrhoea in cattle. In Nigeria powdered seeds are added to brewery waste and given to animals against trypanosomiasis.

Production and international trade *Piliostigma reticulatum* yields many products of local importance. However, no statistics are available on their production and trade. In Burkina Faso small rolls of the bark are sold on local markets as tying material.

Properties The fibre is recorded to be strong. The wood is reddish, darkening to brown. It is heavy, hard, strong and tough. It works well, but the usually small size limits its usefulness. The wood is liable to attacks by termites and borers. It is good fuelwood, because it does not burn fast. The wood fibres in samples from Nigeria were 0.7–1.2 mm long, with a cell wall thickness of c. 5.8 μm.

The bark contains up to 20% tannin. Alkaloids and saponins have been reported present in the roots and bark, and phenolics, triterpenes and phlobatinins in the bark. Fresh leaves contain per 100 g edible portion: water 78.3 g, energy 268 kJ (64 kcal), protein 4.8 g, fat 0.1 g, carbohydrate 14.4 g, fibre 6.8 g, Ca 435 mg, P 80 mg, ascorbic acid 68 mg (Leung, Busson & Jardin, 1968). The leaves have an acidic taste. One kg of fruits contains 55–67 g digestible crude protein. Seeds from Nigeria contained 30.3% crude protein and 27.9% oil. The leaves and the fruits are rich in l-tartaric acid; d-tartaric acid has been isolated as well.

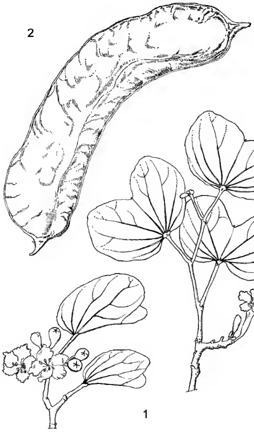
Methanolic root extracts have shown in-vivo anti-diarrhoeal and anti-ulcerogenic properties in rats. Aqueous extracts of the bark showed in-vivo anti-inflammatory and analgesic effects in mice and rats. Ethanolic and aqueous bark extracts showed antibacterial activity. Leaf extracts showed anti-inflammatory activity in the carrageenan-induced rat paw oedema model and antimicrobial activity, especially against Gram positive bacteria. Piliostigmol and various flavonoids isolated from the leaf also showed anti-inflammatory and antimicrobial activity. Methanol extracts from leaves have proved to be trypanocidal against *Trypanosoma brucei brucei* and *Trypanosoma congolense*. Leaf decoctions showed in-vivo anticonvulsant and sedative activity in mice. Butanol and ethyl acetate fractions of the leaf extract exhibited strong antioxidant activity. Quercetin and quercetin glycosides isolated from the ethyl acetate fraction also showed antioxidant activity.

Leaves of *Piliostigma reticulatum* exhibited fast decomposition rate and in the Sahel the plant is considered one of the most promising species to provide organic manure to crops. However, in experiments in Senegal soils amended with leaf residues immobilized nitrogen during the first 62 days, and addition of stems even prolonged the immobilisation period.

Adulterations and substitutes Traditionally, people use *Piliostigma reticulatum* and *Piliostigma thonningii* (Schum.) Milne-Redh. in the same way.

Description Dioecious shrub or small tree up to 10(–15) m tall; bole short, rarely straight, up to 30 cm in diameter; outer bark deeply fissured to cracked, grey to brown, inner bark pink to red; crown rounded and dense; branches grey, waxy and glabrous. Leaves alternate, conspicuously bi-lobed; petiole 1–3.5 cm long, swollen at both ends; blade 5–12 cm × 4–18 cm, cordate or rounded at base, lobes rounded or more or less cuneate, coriaceous, glabrous, greyish-green, palmately veined with 8–11 basal veins. Inflorescence an axillary or terminal panicle, 5–15 cm long, shortly pubescent. Flowers unisexual, c. 2.5 cm in diameter; calyx 5-toothed, 15–20 mm long; petals 5, obovate, white with pink stripes; male flowers with 10 stamens, anthers brown. Fruit an oblong pod 15–30 cm × 2.5–5 cm, straight, undulate or twisted, woody, hard, glabrous or sparsely pubescent, brown, flat, pruinose, sometimes twisted and cracked, indehiscent and persisting, many-seeded. Seedling with epigeal germination.

Other botanical information *Piliostigma*



Piliostigma reticulatum – 1, flowering twigs; 2, fruit.
Redrawn and adapted by Iskak Syamsudin

comprises 3 species in tropical Africa, Asia and Australia. *Piliostigma reticulatum* is frequently confused with *Piliostigma thonningii* due to similarity in appearance, but the latter has larger leaves with hairs on the lower surface, and usually occurs in less dry areas.

Growth and development The growth of *Piliostigma reticulatum* is recorded to be slow. Flowering is in the dry season. In Benin flowering and fruiting occur in October. In drier areas *Piliostigma reticulatum* is semi-deciduous, losing most of its leaves at the end of the dry season, but in more humid zones the leaves are often persistent. The plant resprouts after the stem has been cut. Animals eating the fruits contribute to dispersal of the seeds.

Ecology *Piliostigma reticulatum* occurs from sea level up to 2000 m altitude in areas with an annual rainfall of (200–)400–1000 mm, mainly on heavy and poorly drained soils, but also on sandy soils. It is a pioneer species in woodland, wooded scrubland, wooded grassland, valleys and disturbed habitats such as cultivated fields, fallows and roadsides. The species is common and locally abundant.

Propagation and planting *Piliostigma reticulatum* can be propagated by seed. One kg contains 11,000–14,500 seeds. Germination is poor, but can be improved by soaking the seed successively in 90% H_2SO_4 for 30 minutes and in water for 24 hours, or by soaking them in hot water overnight or in 98% HCl for 90 minutes. Due to the fast growth of the root system, seedlings can be planted out already at 5–7 weeks after sowing.

Management The tree is spared during land preparation and maintained in agroforestry systems. The density of the species in parklands is very variable.

Diseases and pests *Piliostigma reticulatum* is a host of *Caryedon serratus*, a major pest of stored groundnuts. Eggs are laid on the surface of ripe *Piliostigma reticulatum* fruits, after which larvae bore through the husk and into the seed, where larval development takes place, resulting in damaged seeds.

Harvesting The bark is harvested by cutting the branches. It is hard to remove the bark when the stem is dry. For this reason it is recommended to harvest the bark as soon as the stem is cut. The bast is stripped off, dried and used as rope. Mature fruits and young leaves are directly harvested from the plant for various uses.

Handling after harvest *Piliostigma reticulatum* is not exploited for industrial fibre production. The bark is directly collected from cut branches in the field. Sometimes, collectors take the whole stem to their houses before removing the bark. The remaining wood is later used as fuel.

Genetic resources As *Piliostigma reticulatum* has a wide distribution and is common and locally abundant in its distribution area, it is not threatened by genetic erosion.

Prospects *Piliostigma reticulatum* is a valuable multipurpose plant, yielding a wide range of useful products. In Burkina Faso, for instance, it is becoming more and more important, because of the decline of other traditional agroforestry species. Integration of *Piliostigma reticulatum* in the traditional agroforestry systems in semi-arid and arid countries is important for sustainable use of the species. Further research on the domestication potential of the species is worthwhile. The antimicrobial and anti-inflammatory properties warrant further research for pharmaceutical uses.

Major references Aderogba et al., 2006; Arbonnier, 2004; Babajide et al., 2008; Baumer, 1983; Berhaut, 1975b; Burkill, 1995;

Neuwinger, 2000; Salawu et al., 2009; von Maydell, 1986; Yélémou et al., 2007a.

Other references Aderogba et al., 2004; Aderogba, Okoh & Idowu, 2005; Akin-Osanaiye et al., 2009; Atawodi et al., 2003; Aubréville, 1970; Awe & Omojasola, 2009; Ayantunde et al., 2009; Diack et al., 2000; d'Oliveira Feijão, 1961; Dossa et al., 2009; Fortin, Lô & Maynart, 1990; Geerling, 1982; Idu, Ijomah & Omonhinmin, 2002; Khan, 2001; Leung, Busson & Jardin, 1968; Ngo Bum et al., 2009; Sembène & Delobel, 1998; Toutain, 1980; Yélémou et al., 2007b; Youmbie, 2008.

Sources of illustration Andrews, 1952.

Authors F.G. Vodouhê, S. N'danikou & E.G. Achigan-Dako

PILIOSTIGMA THONNINGII (Schumach.) Milne-Redh.

Protologue Hooker's Icon. Pl. 35: 2, t. 3460 (1947).

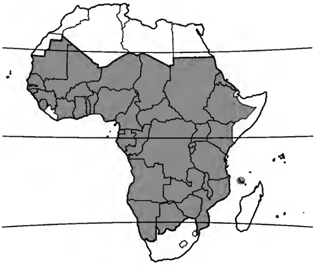
Family Caesalpiniaceae (Leguminosae - Caesalpinioideae)

Chromosome number $2n = 24, 26$

Synonyms *Bauhinia thonningii* Schumach. & Thonn. (1827).

Vernacular names Camel's foot, camel's foot tree, monkey bread, wild bauhinia, picture-frame tree (En). Pied de bœuf (Fr). Mchikichi, mchekeche, msegese, mkoma, msabuni (Sw).

Origin and geographic distribution *Piliostigma thonningii* is native to tropical Africa. It is widespread in the Sudano-Guinean region from Senegal eastward to Eritrea and occurs southward to Namibia, Botswana, Mozambique and South Africa. It also occurs in Yemen.



Piliostigma thonningii – wild

Uses The bark is commonly used for tying, for instance in hut, fence and bridge building. In Sudan and Mozambique the inner bark is used for binding an arrowhead to its shaft. The bark was formerly made into barkcloth. Fibres extracted from the bark are widely used for making string, rope and cloth. Root fibres are made into rope as well. The leaves are used for wrapping food, and twigs and roots serve as toothbrushes. The dried fruit is used to smooth pottery, and the roots are used for giving a glaze to gourds.

The bark provides tanning material and yields a red-brown dye used for cloth and wooden tools. The root yields a red-brown or black dye, and the fruit and seeds a black or blue one. In Ghana, Nigeria and DR Congo women chew the root-bark to redden their lips; the bark is also rubbed on the lips to colour these red. Hausa in Nigeria stain their teeth red by chewing the bark.

The fruit is eaten as a snack or as an emergency food, especially by children and herdsmen. In times of scarcity the fruits are ground and boiled into porridge or made into drinks. In Sudan the roasted seeds are eaten. In Kenya the bark is eaten in times of severe food shortages. Maasai people in East Africa chew the leaves as thirst-quencher. The foliage and fruits are browsed by cattle and other livestock. The flowers are a substitute for tobacco, and the roots are used to increase the strength of tobacco. Mature fruits are burnt to obtain a salt.

The tree provides poles and timber for local house construction. The wood is also used for kitchen utensils, tool handles, furniture, bedposts, wheel-work and carpentry. The Maasai make bows from the wood. The wood is used as firewood and for making charcoal.

The unripe fruits are used as a soap substitute, and the ash of ripe fruits is also used in soap making. In Côte d'Ivoire dried leaves are used together with those of *Parinaria curatellifolia* Planch. for making gunpowder. Infusions of the bark, leaf or pod are used to coagulate *Funtumia* latex in making rubber. The bark yields a gum that swells and softens in water and is used for caulking. A resin obtained from the unripe fruit is used as glue for fastening the iron parts of tools and spears to the handles.

Piliostigma thonningii is an agroforestry tree, suitable for intercropping with crops. It provides good shade and serves as shelterbelt in homesteads when in full foliage. It is used in live fences around fields and as a live support for vines of weaker plants. Honeybees forage for abundant pollen and nectar in dry land areas and the tree is recommended for planting to increase honey production.

Piliostigma thonningii is widely used in African traditional medicine. Root preparations are applied on wounds and ulcers as a haemostatic and to promote healing. They are also used as a diuretic and for the treatment of diarrhoea, dysentery, worms and other intestinal problems. Cough remedies are prepared from the root as well. Various root preparations are taken or applied in case of snake bites, and in DR Congo roots serve as antidote to poisonous plants. In DR Congo and Malawi the roots are used to treat rheumatism. The root heated in fat is used as a poultice in case of a painful spleen. Root decoctions are drunk to prevent miscarriage. Root decoctions or infusions are taken in case of heavy menstruation and a painful uterus, and given to a mother that has given birth. Root infusions are taken to promote conception and against venereal diseases. They are used in baths against vertigo. In Uganda the root is smoked against insanity, and in Zimbabwe the powdered root is eaten against convulsions.

Bark preparations are remedies against cough, colds, chest pain, pneumonia, diarrhoea, dysentery, worms and other intestinal problems, and snakebite. They are also applied on wounds, ulcers and skin infections. The bark is credited with pain-relieving activity, and is used for the treatment of sore throat, toothache, gum problems, earache, stomach-ache and general body pain. Bark decoctions are rubbed in or used as a vapour bath for the treatment of rheumatism, muscular pain and bone inflammation. They are also taken as an antiemetic. Infusions of the bark are taken for the treatment of internal abscesses and haematuria, and infusions of the bark and leaf are used against malaria. In East Africa bark sap, or the bark boiled in milk or in soup, is drunk for the treatment of gonorrhoea. In Gambia sap from the bark is used to induce dizziness in dancers. The ash of young wood is rubbed in with oil against chest complaints.

Leaf preparations are used for the treatment of diarrhoea, dysentery, worms and other intestinal problems. They are also used against cough and other respiratory problems throughout tropical Africa. In Zambia, for instance, the leaves are boiled in water and the steam is inhaled. Various leaf preparations are used as antiseptic and cicatrisant to promote wound healing, and against skin diseases, itching and snake bites. Pounded leaves are rubbed on the head in case of headache, whereas leaves boiled in water are rubbed on the back against lumbago. A leaf decoction is added to bath water against stiffness. In case of toothache, a leaf infusion or decoction is drunk or the boiled leaves are chewed. In Zimbabwe the leaves are boiled and the strained liquid is rubbed into incisions for the treatment of painful legs. Leaf decoctions are drunk or used in baths or vapour baths against fever. A decoction of the leaves is used as a vaginal wash and enema to a mother giving birth. In case of epilepsy and possession leaf decoctions are drunk or used for bathing. Leaf decoctions are used as a wash on fractures and the residue is massaged on the part affected. In case of bone inflammation a steam bath of the leaves boiled in water is taken. In southern Africa leaf decoctions or infusions are taken in case of heavy menstruation. Leaf infusions are used as anti-emetics. Leaf sap or infusions are applied for the treatment of eye problems. In Côte d'Ivoire a paste made from ground young leaves and flower buds is diluted with water and drunk against palpitations. In Senegal the leaves are used in the treatment of dementia.

Powdered dried flowers are eaten in food, drunk in water or smoked like tobacco against cough. The fruit is an ingredient of preparations used for the treatment of cough, bronchitis and headache. Scrapings of the fruit are applied as a dressing on wounds.

Production and international trade *Piliostigma thonningii* yields a wide range of useful products, but no statistics are available on their production and trade.

Properties The bast fibre of *Piliostigma thonningii* is recorded to be long and strong.

The heartwood is pinkish to dark brown, the sapwood pale brown. The wood has an air-dry density of about 750 kg/m^3. It is easy to work, but liable to attack by termites and borers. The usually small size limits its usefulness. It is good fuelwood, burning long, providing a hot flame and giving little smoke.

The fruit contains per 100 g edible portion: water 5.0–9.8 g, energy 1089–1185 kJ (260–283 kcal), protein 6.3–6.9 g, fat 1.8–3.2 g, carbohydrate 54.6–58.9 g, Ca 360 mg, Fe 40 mg (Irvine, 1961). Pod meal is said to be pleasantly scented. Fruit meal from Zimbabwe contained per 100 g dry matter: crude protein 7.8 g, neutral detergent fibre 44.6 g, ether extract 3.2 g and crude ash 4.8 g. The in-vivo degradability of dry matter and crude protein in Holstein-Friesian steers was 33.4% and 29.8%, respectively, and it was concluded that the meal could be a useful feed supplement to cattle grazing poor quality forage during the dry season. Per 100 g seeds from Nigeria contained: moisture 6.7 g, crude protein 30.3 g, crude fat 1.4 g, carbohydrate 23 g, crude fibre 35.0 g. Dried leaves contain per 100 g: water 9.3 g, protein 9.6 g. Epicatechin and inositol derivatives were isolated from the fruits. Screening of the seeds revealed the presence of saponins, flavonoids, phenolics, anthraquinones and glycosides.

The tannin content of the bark of smaller twigs is about 20%. In the bark of the roots and larger branches the tannin content is lower, about 18%.

Root, bark and leaf extracts showed antiviral activity against Herpes simplex virus type 1 and 2 (HSV-1, HSV-2), HIV and different strains of influenza and syncytial viruses. The roots, leaves and stems showed in-vitro activity against the tapeworm *Hymenolepis diminuta* ('rat tapeworm').

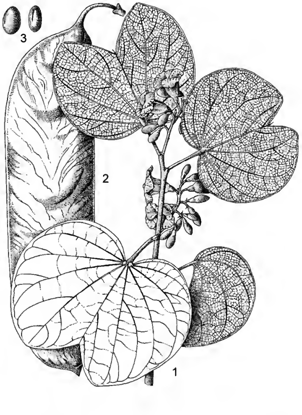
The polyphenol fraction of the root bark has shown in-vivo antitussive and bronchodilator activity in guinea pigs, whereas in mice it showed anti-inflammatory and analgesic activity against phenylquinone-induced writhing.

Stem bark extracts exhibited antibacterial activity against *Bacillus subtilis*, *Corynebacterium pyogenes*, *Escherichia coli*, *Proteus vulgaris*, *Shigella dysenteriae* and *Staphylococcus aureus*. An ethanolic extract of the stem bark induced persistent contractions of the isolated guinea pig ileum. Bark extracts have shown in-vitro larvicidal activity against intestinal parasites of cattle. An ethanolic extract of the bark showed anthelmintic activity, and D-3-O-methylchiroinositol isolated from the stem bark showed anthelmintic activity against *Haemonchus contortus* larvae from faecal samples of infected lambs. The presence of alkaloids is reported for the bark.

Leaf extracts showed anti-inflammatory and antimicrobial activity. An aqueous leaf extract caused constriction of blood vessels in isolated rat aortic rings and reduced bleeding times in rats, which confirms the traditional medical application of the leaves in arresting bleeding. Butanol and ethyl acetate fractions of the leaf extract exhibited strong antioxidant activity. Piliostigmin (a new 2-phenoxychromone) and three C-methylflavonols (6,8-di-C-methylquercetin 3-methyl ether, 6-C-methylquercetin 3,7-dimethyl ether and 6,8-di-C-methylquercetin 3,7-dimethyl ether) were isolated from the leaves. Some of these C-methylflavonols have shown anti-inflammatory and antibacterial activity. Quercetin and quercitrin are present in the leaf. The leaves and the fruits contain l-tartaric acid.

Adulterations and substitutes *Piliostigma thonningii* is frequently confused with *Piliostigma reticulatum* (DC.) Hochst. Traditionally, people often use both species in the same way.

Description Deciduous, dioecious tree up to 10(–40) m tall, sometimes shrubby; bole branchless for 2–3 m, twisted, up to 30(–35) cm in diameter; outer bark rough, longitudinally fissured, dark brown to grey or black, inner bark fibrous, pink to dark red-brown when cut; crown spreading; branches with rusty-brown tomentum, somewhat glabrescent later. Leaves alternate, conspicuously bi-lobed for one eighth to one third of the length; stipules 3–6 mm long, deciduous; petiole 2–5(–7) cm long, pubescent; blade up to 17 cm × 21 cm, base usually strongly cordate, apex of lobes rounded to acute, leathery, upper surface glabrous, lower



Piliostigma thonningii – 1, branch with female flowers; 2, fruit; 3, seeds.
Redrawn and adapted by Achmad Satiri Nurhaman

surface with rusty-brown crisped hairs and conspicuous reticulate venation, palmately veined with 11–15 basal veins. Inflorescence a panicle, usually alternately leaf-opposed and axillary along branches, male inflorescence very narrowly pyramidal, up to 25 cm × 5.5 cm; female inflorescence up to 7 cm long, few-flowered; axes brown-tomentellous. Flowers unisexual, fragrant; calyx cupular, 1–2.5 cm long, 5-lobed, brown-tomentellous; petals 5, obovate, 1–2.5 cm long, wrinkled, margin strongly undulate, white to lilac or pink; stamens 10(–11), scarcely reaching the throat of the flower, reduced to staminodes in female flowers; ovary brown-tomentose, rudimentary in male flowers; style very short or absent; stigma capitate. Fruit an oblong to linear-oblong pod 12–30(–37) cm × 3–7 cm, woody, brown-pubescent when young but later glabrescent, persisting on the tree but finally decaying on the ground, many-seeded. Seeds obovoid to ellipsoid, 4–9 mm × 2–7 mm × 3–4 mm, dark brown to blackish, compressed. Seedling with epigeal germination.

Other botanical information *Piliostigma* comprises 3 species in tropical Africa, Asia and Australia. *Piliostigma thonningii* is frequently confused with *Piliostigma reticulatum* due to similarity in appearance, but the former has larger leaves with hairs on the lower surface, and usually occurs in less dry areas.

Growth and development Growth rates up to 60 cm per year have been recorded, but in an annually burnt zone in Côte d'Ivoire an average annual growth of only 4.5 cm was recorded over a period of 20 years for trees larger than 2 m at the start of this period. The tree becomes nearly leafless in the dry season. Flowering occurs in the dry season or after the first rains, shortly after the leaves have emerged. In the Sahel *Piliostigma thonningii* flowers in December–June. In Ethiopia flowering happens from November to March and fruiting from May to September, while in southern Africa the flowering time is from November to June and fruiting from March to October. Root suckers develop from exposed roots. Juvenile individuals are susceptible to fire damage, but *Piliostigma thonningii* survives fire through quick resprouting of above-ground structures.

Ecology *Piliostigma thonningii* occurs from sea level up to 2200 m altitude in areas with an average annual temperature of 20–21°C, an average annual rainfall of (400–)600–1200(–1500) mm, and a dry season of 6–8(–11) months. It is sensitive to frost. It grows on any soil type, but heavy clayey soils or medium loamy soils are preferred. *Piliostigma thonningii* is common in secondary and gallery forest, woodland, wooded grassland and bushland, often in river valleys, and in disturbed locations. It is often left in cultivated fields and it rapidly colonises abandoned areas.

Propagation and planting Natural regeneration, direct sowing, and planting out of seedlings or root suckers can be used for propagation. The number of seeds per kilogram is 7300–8500. Seed collection should be done soon after the fruits turn brown, to prevent insect attack. Appropriate seed drying is also important, in order to prevent seed decay. The seeds are difficult to extract. This is done by drying the fruits in the sun, cutting them into pieces and separating the seed from the pulp. Seeds can be stored for several years in cool, dry, insect-free conditions. Seeds usually germinate 5–10 days after sowing. Seed pre-treatments such as washing, soaking in water for up to 24 hours, hot water treatment and scarification usually improve germination.

Successful in-vitro plant regeneration has been achieved with hypocotyl explants cultured in auxin-supplemented Murashige and Skoog (MS) medium.

Management *Piliostigma thonningii* is usually collected from the wild and not planted or protected. Lopping, pollarding, trimming and coppicing are possible. In Tanzania fruits are collected in the dry season, and they can be stored for about 4 months.

Diseases and pests The seeds of *Piliostigma thonningii* are damaged by the bruchid *Caryedon serratus*, a major pest of stored groundnuts. Eggs are laid on the surface of ripe *Piliostigma thonningii* fruits, after which larvae bore through the husk and into the seed, where larval development takes place, resulting in damaged seeds.

Handling after harvest The bark is stripped off the tree for immediate use or the bark is peeled off and the fibre is separated from the outer bark for making ropes. For this, the fibre should first be sun or air dried. After drying, the fibre will be immersed in water to make it easily flexible prior to utilization. Twine is made by dampening coarse fibres and rolling two strands between palm and thigh. Rope is made by twisting thicker strands. Dry, coarse fibre can be kept for some time without deteriorating, and will regain resilience when dampened.

To prepare drinks, the fruits are pounded and the powder is soaked in water, after which the liquid is stirred. To obtain dye in Burkina Faso, the bark is pounded, boiled and macerated.

Genetic resources *Piliostigma thonningii* is widespread in tropical Africa and not threatened by genetic erosion. However, collection and conservation of genetic resources from various regions are recommended to investigate genetic and phytochemical variations in populations.

Prospects *Piliostigma thonningii* is widely used as a fibre plant and for a range of other purposes, making it an important multipurpose tree in semi-arid and subhumid regions. Unfortunately, very little information is available on the fibre properties. However, because of the extensive utilisation of the tree and the isolation of many pharmacologically active compounds, investigations on domestication and cultivation practices is certainly worthwhile.

Major references Aderogba et al., 2004; Akinpelu & Obuotor, 2000; Arbonnier, 2004; Bekele-Tesemma, 2007; Burkill, 1995; Ibewuike et al., 1996; Neuwinger, 2000; Thulin, 1989; von Maydell, 1986; World Agroforestry Centre, undated.

Other references Aderogba et al., 2006; Asuzu, Gray & Waterman, 1999; Asuzu & Onu, 1994; Ayisire, Akinro & Amoo, 2009; Baumer, 1983; Berhaut, 1975b; Bombardelli, Morazzoni & Mustich, 1995; Bombardelli et al., 1994; Brummitt et al., 2007; Chilufya & Tengnäs, 1996; Dauget & Menaut, 1995; Ibewuike et al., 1997; Igoli, Igwue & Igoli, 2003; Irine, 1961; Jimoh & Oladiji, 2005; Mandibaya & Chihora, 1999; Nacro & Millogo-Rasolodimbi, 1993; Ozolua, Alonge & Igbe, 2009; Ruffo, Birnie & Tengnäs, 2002; SEPASAL, 2009e.

Sources of illustration Brenan, 1967a.

Authors D. Lemessa

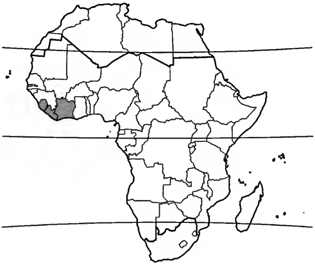
PLACODISCUS SPLENDIDUS Keay

Protologue Bull. Jard. Bot. Etat 26(2): 197 (1956).

Family Sapindaceae

Origin and geographic distribution The distribution of *Placodiscus splendidus* is restricted to Sierra Leone, Liberia and Côte d'Ivoire.

Uses In Sierra Leone the leaf petioles and rachis are bundled together to serve as a broom.



Placodiscus splendidus – wild

Botany Small tree up to 10 m tall, unbranched or little branched with the leaves clustered at the top; bark grey-brown, longitudinally grooved. Leaves alternate, paripinnately compound with (6–)8–12 pairs of subopposite leaflets; petiole 9–18 cm long; rachis 25–50 cm long; petiolules 3–6 mm long; leaflets elongate-oblong to oblong-lanceolate, 5–23 cm × 1.5–5 cm, cuneate at base, acuminate at apex, underside with small glandular and non-glandular hairs, pinnately veined with 11–15 pairs of lateral veins. Inflorescence a raceme up to 15 cm long, hairy. Flowers sessile or subsessile, functionally unisexual; calyx 5-merous with tube about as long as lobes, c. 4 mm in diameter, pinkish brown; petals absent; stamens 8, free; ovary superior, 3-lobed and 3-celled; male flowers with rudimentary ovary, female flowers with reduced stamens. Fruit an ovate capsule c. 3 cm long and wide, indehiscent, hard, yellow when ripe, short-hairy when young, later glabrescent, 3-lobed but only 1–2 lobes developed.

Placodiscus splendidus flowers in August–September, and fruiting is in October.

Placodiscus comprises about 20 species, distributed from Guinea Bissau eastward to Tanzania.

Ecology *Placodiscus splendidus* occurs in the understorey of forest and secondary vegetation.

Genetic resources and breeding As the distribution of *Placodiscus splendidus* is rather restricted, loss of habitat may be a serious threat but very little has been published on the species.

Prospects Unless new insights arise, *Placodiscus splendidus* will remain of localized interest only.

Major references Burkill, 2000; Hall, 1980; Keay, 1958g.

Other references Fouilloy & Hallé, 1973; Hawthorne & Jongkind, 2006; Keay, 1956.

Authors C.H. Bosch

PODOCOCCUS BARTERI G.Mann & H.Wendl.

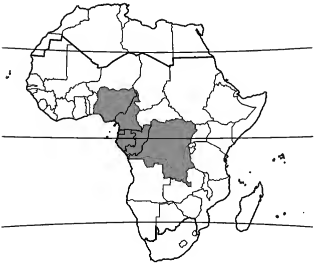
Protologue Trans. Linn. Soc. London 24(3): 426 (1864).

Family Arecaceae (Palmae)

Origin and geographic distribution *Podococcus barteri* is distributed from Nigeria to DR Congo and Cabinda (Angola), never more than 200 km inland.

Uses In Gabon the leaves are used for covering temporary huts when leaves of more desirable species are not available. The leaf rachis is used for weaving fish-traps and the whole rachis is used as a fishing rod. In Equatorial Guinea the leaf base is used as a chew stick to clean the teeth, and in Cameroon the beaten stem is similarly used. The stems are used for making furniture. The fruit pulp and the fresh seeds are eaten.

Botany Small, monoecious, slender, unarmed palm; stem up to 2(–3) m tall, up to 1 cm in diameter, covered in reddish brown fibrous leaf bases, eventually bare and with annular leaf scars, with basal axillary stolons; prop roots present. Leaves few, 50–120 cm long, pinnately compound with up to 7 leaflets on each side of the rachis; sheath up to c. 15 cm long, tubular, becoming split opposite the petiole, densely covered in red-brown woolly tomentum, margins fibrous; petiole slender, up to 50 cm long, narrowly channelled above, rounded below; rachis like petiole but longer; leaflets alternate to subopposite, rhomboid, single-fold, up to 30 cm × 12 cm, lower ones smaller, basal half with entire margin, upper half with toothed margin, membranous, glabrous above, sparsely hairy below. Inflorescence solitary, between the leaves, spike-like, c. 75 cm long, initially erect, pendulous when fruiting, protandrous, many-flowered; peduncle slender, up to 50 cm long; prophyll tubular, 2-keeled, dark brown, disintegrating into long fibres; peduncular bracts 2–3, tubular, disintegrating as prophyll; rachis about as long as peduncle or longer, bearing spirally arranged triads of 2 distal male flowers and 1 proximate female flower, or paired or solitary male flowers distally. Flowers enclosed in pits, unisexual, 3-merous, bracteoles membranous, sepals distinct, petals valvate, about twice as long as sepals, adnate to receptacle; male flowers with 6 stamens in 2 whorls and short pistillode; female flowers with connate petals, staminodes 6, ovary superior and (1–)3-celled, stigmas 3. Fruit a drupe, 1–3-lobed, ellipsoidal or with ellipsoidal lobes, 2–3.5 cm × 0.5–1.5 cm, often slightly curved, orange-red to brown, fragrant when ripe, 1–3-seeded; exocarp smooth, leathery; mesocarp gelatinous with inner layer of fibres; endocarp crustaceous. Seed narrowly ellipsoidal, c. 19 mm × 4 mm.



Podococcus barteri – wild

Podococcus comprises 2 species. *Podococcus acaulis* Hua, a small palm up to 3(–4) m tall distributed in Gabon and Congo, was previously considered conspecific with *Podococcus barteri*. It can be distinguished from *Podococcus barteri* by the absence of a stem, its clustering habit, its leaves densely hairy below, its erect infructescence and its purplish brown fruit.

Podococcus barteri is extremely slow growing and lives long. In Cameroon the total lifecycle was estimated at about 70 years. Adult palms produce one leaf per year, and each leaf remains about 5 year in the crown. Natural vegetative reproduction takes place through stolons growing horizontally above, on or under the soil-surface, with the apex eventually growing upward and roots being formed at the bend. In Cameroon it has been estimated that seedlings start vegetative reproduction after 15 years and flowering after 37 years, while vegetatively produced palms start vegetative reproduction after 4 years and flowering after 26 years. Flowering is protandrous, with the male flowers being shed several weeks before female flowering. In Cameroon the period from initial emergence of the spathe to seed maturation is about 17 months. Flowering and fruiting is year-round.

Ecology *Podococcus barteri* occurs from sea-level up to 700 m altitude in areas with an average annual rainfall of 1500–2400 mm. It is found in the undergrowth of evergreen forest, and in relatively dry locations in swamp forest and on river banks. It persists in logged forest but is absent from young secondary vegetation.

Management The 1000-seed weight is c. 600 g.

Genetic resources and breeding *Podococcus barteri* is fairly widespread, but highly localised with many disjunctions and it is extremely slow growing. Although it is presently not included in the IUCN Red list of threatened species, it may become classified as vulnerable in the future.

Prospects *Podococcus barteri* is only locally used as a source of thatch, fishing material, chew sticks and edible fruits. There is no reason to expect that its importance will increase in the future. In view of the slow growth rate, care should be taken in the exploitation of this palm.

Major references Bullock, 1980; Burkill, 1997; Raponda-Walker & Sillans, 1961; Uhl & Dransfield, 1987; van Valkenburg & Sunderland, 2008.

Other references Blach-Overgaard et al., 2010; d'Oliveira Feijão, 1961; Johnson, 1998d; Letouzey, 1978; Russell, 1968; Vivien & Faure, 1988; Vivien & Faure, 1996; Walker, 1931; Wright, 1901–1902.

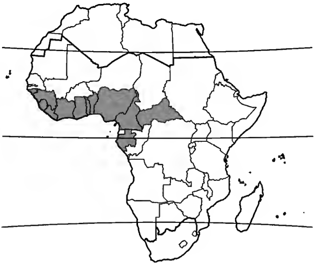
Authors M. Brink

POLYGALA BUTYRACEA Heckel

Protologue Bull. Geogr. 13: 222 (1889).

Family Polygalaceae

Origin and geographic distribution *Polygala butyracea* is only known as a cultivated and naturalized plant. It has a fairly wide, disjunct distribution which may be the result of a more widespread area of ancient cultivation that has been contracting since. There used to be 3 centres of cultivation: the first from Guinea Bissau to western Côte d'Ivoire; the second in northern Togo and Benin and the third in northern Cameroon and adjacent areas in Nigeria and the Central African Republic. Records for Ghana are substantiated by herbarium vouchers and for Gabon it is mentioned in a single source but there are no herbarium vouchers. The introduction of groundnut (*Arachis hypogaea* L.), sesame (*Sesamum indicum* L.) and black sesame (*Hyptis spicigera* Lam.) in Africa is probably responsible for the gradual disappearance of *Polygala butyracea* as a crop.



Polygala butyracea – planted and naturalized

Uses In Cameroon, Nigeria, Central African Republic and Gabon *Polygala butyracea* is primarily grown for its bark fibre. In Nigeria the fibre is made into thread used for weaving bags and cloth and producing fishing lines and nets. In Gabon the fibre is used for making cordage, while the seed is used as an expectorant. From Benin westwards *Polygala butyracea* is mainly grown for the seed oil or fat that is used for cooking. The fat is known as 'cheyi fat', 'malukang butter' and 'ankalaki butter'. The seeds are heated or fried and ground and the resulting dry, yellow meal is added to foods such as soups and meat dishes.

Properties The fibre of *Polygala butyracea* is similar to that of sunn hemp (*Crotalaria juncea* L.). Mature and dried seed contains up to 59% oil and 10% protein. The oil is pale yellow and has a nutty flavour. The fatty acid composition of the seed oil is: palmitic acid 62%, oleic acid 32% and myristic acid 6%. The oil also contains phospholipids (1.5%).

Botany Annual (or perennial) herb 200–270 cm tall, single-stemmed or weakly branched, stems soft hairy. Leaves alternate, entire; blade linear, acute at apex, 8–16 cm × 0.5–1 cm, midrib prominent. Inflorescence a long, terminal raceme, subtended by a persistent bract, 3–5 mm long, bracteoles 2, 1–2 mm long. Flowers bisexual, zygomorphic, white, creamy to pinkish; pedicel 2.5–3 cm long; sepals 5, free, persistent, unequal, 2 inner ones largest, petaloid, c. 10 mm × 6 mm, glabrous on the outside; petals 3, 2 upper ones basally fused with staminal tube, lower one boat-shaped (keel), clawed; stamens 8, monadelphous, anthers basally attached, opening with a terminal pore; ovary laterally compressed, 2-celled, each locule with 1 ovule. Fruit an elliptical capsule c. 8 mm long, compressed, narrowly winged, dehiscing by a marginal split. Seed c. 6 mm long, dark, glabrous with hairs at top and bottom, at micropilar side with small caruncle. Seedling with epigeal germination; cotyledons ovate, rounded; first pair of leaves ovate to elliptical, reddish green.

Polygala is a cosmopolitan genus comprising about 750 species, with just over 200 species in tropical Africa. In a recent revision of the African species of *Polygala*, the genus is subdivided in subgenera, sections and subsections. *Polygala butyracea* is placed in *Sativae*, a subsection with 30 species. All *Polygala* species with a documented fibre use are placed in this subsection. *Polygala cristata* P.Taylor and *Polygala baikiei* Chodat are suggested as possible ancestors of *Polygala butyracea*. *Polygala cristata* differs by its considerably smaller, hairy seeds, and it is only known from Guinea, Sierra Leone, Liberia and Côte d'Ivoire. The name *Polygala gomesiana* has been misapplied for *Polygala exelliana* Troupin of which the bark fibres are used in south-western Tanzania for making twine and rope. In DR Congo the roots are cooked and eaten. It also occurs in Zambia and Malawi, and an infusion of the roots is used as a remedy for coughs. *Polygala macrostigma* Chodat is an annual herb more than 1 m tall, native to DR Congo, Uganda, Tanzania and Angola. In DR Congo the bark fibres are used for tying and for making cords, while the leaves and seeds are consumed. In Malawi the roots are chewed as a cure for coughs. The bark fibres of *Polygala nambalensis* Gürke, *Polygala sparsiflora* Oliv. (synonym: *Polygala ukirensis* Gürke) and *Polygala usafuensis* Gürke are used in DR Congo for making rope.

Ecology *Polygala butyracea* is restricted to cultivated fields up to 600 m altitude, and is occasionally found as an escape of cultivation. It grows fairly well on poor soils.

Management In Sierra Leone *Polygala butyracea* has been grown as a dry-season crop in rice fields. In Nigeria it is grown in a mixed cropping system with yams. When appearing as a weed in annual crops it is spared until the seeds are mature and can be harvested. Flowering of *Polygala butyracea* starts towards the end of the rainy season and continues for several months. As long as the plants remain green the seeds are not shattered. The uneven ripening of the seeds is a disadvantage for commercial cultivation for oil production.

Genetic resources and breeding As *Polygala butyracea* is restricted to cultivated fields (with occasional naturalization) and its cultivation is declining, it is likely to be threatened with genetic erosion. Germplasm collection and evaluation of *Polygala butyracea*, its assumed ancestors and other closely related species is long overdue.

Prospects It may be worthwhile to investigate possibilities for genetic improvement through selection and improvements in cultivation measures.

Major references Burkill, 1997; Chevalier, 1924; Kirby, 1963; Paiva, 1998; Portères, 1950.

Other references Bedigian, 2004; Chevalier & Jacques-Félix, 1938; Chillou, 1924; Exell, 1960; Garine, 2005; Heckel, 1987; Heckel & Schlagdenhauffen, 1889; Paiva, 2007; Petit, 1958; Raponda-Walker & Sillans, 1961; Zeven & Zhukovsky, 1975.

Authors C.H. Bosch

POUZOLZIA MIXTA Solms

Protologue Sitzungsber. Ges. Naturf. Freunde Berlin 1864: 1 (1864).

Family Urticaceae

Synonyms *Pouzolzia hypoleuca* Wedd. (1869), *Pouzolzia baronii* Leandri (1951).

Vernacular names Soap nettle, snuggleleaf, soap bush (En). Chopo (Sw).

Origin and geographic distribution *Pouzolzia mixta* is distributed from Sudan and Ethiopia southward through Tanzania, Malawi, Zambia and Angola to Namibia, Botswana, Zimbabwe, Mozambique, South Africa and Swaziland. It also occurs in Madagascar and in Yemen. The distribution shows a particular disjunction, as it is absent from Kenya and probably from Uganda as well.

Uses Fibre from the bark is used for rope and string. It was formerly much used for fishing nets in Malawi, before nylon nets became popular. Thin strips of bark fibre have been used to stitch wounds in Zimbabwe, and are thought to have healing effects. The leaf is cooked as a vegetable often together with that of *Obetia tenax* (N.E.Br.) Friis. The crushed leaf is used as a substitute for soap to wash hands and clothes. Children use the leaves, which can be made to stick together, to fashion cups, baskets and hats. Furthermore, the plant is used as an ornamental, and is a source of bee forage.

Pouzolzia mixta finds wide application in African traditional medicine. A root extract or root decoction is taken for the treatment of diarrhoea and dysentery. An infusion of the root is drunk to treat constipation, venereal diseases and female sterility, and as an aphrodisiac and contraceptive. Root powder is inserted into the vagina against female sterility and to prevent abortion. A root infusion is instilled into the vagina to dilate the birth canal during labour. A maceration of the root and leaves is drunk to expel the placenta after childbirth, or an infusion of the root or bark is instilled into the vagina for this purpose. The powdered root is taken in porridge against uterine pain. A paste of the root is applied on burns and a depressed fontanel. A decoction of the stem is administered as an enema for the relief of biliousness. The pounded leaf is mixed with water to form a drink taken for treatment of measles.

Properties The ultimate fibres of material from Malawi were (6–)11(–26) mm long and (23–)30(–40) µm wide. The fibre contained 66.7% cellulose. The stem contains a high amount of gums, like that of ramie, making degumming of the fibre necessary. Experiments showed that the fibre can be degummed fairly easily. Reports on the strength of the fibre are inconsistent. The wood is soft.

Botany Deciduous shrub or small tree up to 3(–5) m tall, devoid of stinging hairs; stems juicy, with wide spongy pith or hollow centre; outer bark longitudinally striate, greyish or reddish brown, with prominent scars of leaves and inflorescences; young branches reddish, densely hairy, glabrescent. Leaves alternate, simple; stipules ovate to lanceolate, up to 5 mm long, acute to acuminate at the apex, membranous, red-brown, hairy; petiole 0.5–2(–3) cm long, densely hairy; blade ovate to lanceolate, 2–11.5 cm × 1–7.5 cm, base obliquely cuneate to rounded or truncate, apex attenuate-acute to acuminate, margin entire, upper surface dark green and velvety or rough, with stiff hairs and point-shaped mineral concretions, lower surface arachnoid to white-felted, 3-veined from the base, with 2–3 pairs of lateral veins. Inflorescence an axillary cluster, sessile, male or bisexual with many more male flowers than female ones; bracts narrowly ovate, up to 1 mm long. Flowers unisexual, greenish white; male flowers on pedicel c. 1 mm long, (4–)5-merous, 15–2.5 mm long, tepals densely hairy; female flowers sessile, 1–3 mm long, constricted at the toothed apex, hairy, with 3–8 longitudinal ridges of which 2 usually larger than the rest, ovary superior, enclosed in the perianth, stigma protruding. Fruit a more or less compressed achene 1.5–2.5 mm long, smooth, shiny, white to dark brown, surrounded by the persistent perianth.

In southern Africa *Pouzolzia mixta* generally flowers in November–December and fruits in December–February.

Pouzolzia comprises 36 species, mainly in the Old World tropics. *Pouzolzia denudata* De Wild. & T.Durand (synonym: *Pouzolzia andongensis* Hiern), an annual herb up to 2(–3) m tall distributed from Côte d'Ivoire eastward to Ethiopia and Uganda, and southward to Angola, is recorded to be exploited for its fibre in Angola, but details on this use are lacking. The fibre is white, and the ultimate fibres are 10–20 mm long and (2.5–)13–22(–30) µm wide, with a cell wall thickness of 5.5–6 µm. The bark contains about 15% fibre. In DR Congo the leaf is eaten as a vegetable. The roasted leaf is applied to promote healing of circumcision wounds. Leaf pulp mixed with palm oil is rubbed in for the treatment of goitre. The leaf is used for treatment of eye diseases in dogs.

Ecology *Pouzolzia mixta* occurs in drier areas at 100–1900 m altitude, in wooded grassland, open deciduous woodland, wooded ravines and riverine thickets and forest, usually in rocky locations, sometimes on sand.

Management *Pouzolzia mixta* is usually collected from the wild, but in Malawi it has often been planted in fishing villages. It can be propagated by seed.

The traditional method to obtain fibre for fishing nets in Malawi was to scrape off the outer bark, and to dry the remaining stems in the sun. Later they were soaked in water and partially dried, after which the white inner bark fibre could be peeled off easily. The inner bark was dried and separated into narrow strips. String was made by rolling out these strips with the palm of the hand on the thigh. The various lengths were spliced and rolled together into long skeins of string, which varied from fine to thick, according to the intended purpose.

In Tanzania tender leaves to be eaten as a vegetable are collected in the rainy season. They are chopped and cooked with coconut milk or pounded with groundnuts, and served with ugali or rice.

Genetic resources and breeding As *Pou-*

zolzia mixta is widely distributed and locally common, it is not threatened by genetic erosion.

Prospects *Pouzolzia mixta* is a useful local source of fibre for cordage. The absence of stinging hairs gives it an advantage over other *Urticaceae*. The fibre is much shorter than that of ramie and needs degumming, whereas reports on its strength vary. Therefore, commercial exploitation of this fibre does not seem a viable option. The lack of interest in *Pouzolzia mixta* and other representatives of the genus from pharmacologists is surprising, as medicinal use is common.

Major references Coates Palgrave, 1983; Friis & Immelman, 2001; Nsiku, 2003; Ruffo, Birnie & Tengnäs, 2002; Wilmot-Dear & Friis, 2006.

Other references Chinemana et al., 1985; Gelfand et al., 1985; Jacques-Félix & Rabéchault, 1948; Kirby, 1963; Medina, 1959; Neuwinger, 2000; SEPASAL, 2009f; van Wyk & Gericke, 2000; Watt & Breyer-Brandwijk, 1962; Williamson, 1955.

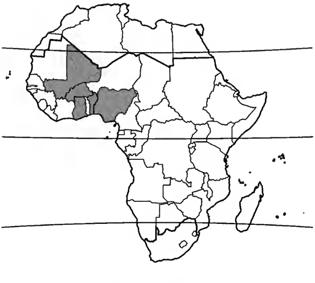
Authors M. Brink

PTELEOPSIS HABEENSIS Aubrév. ex Keay

Protologue Kew Bull. 1953: 290 (1953).

Family Combretaceae

Origin and geographic distribution The area of distribution of *Pteleopsis habeensis* is restricted to only a few regions: the Bandiagara escarpments in Mali (with the plant population possibly extending into Burkina Faso), the Akosombo and Bui regions in Ghana, and the Yankari Game Reserve and its immediate surroundings in Nigeria. It is possibly also present in Benin.



Pteleopsis habeensis – wild

Uses In the Bandiagara area of Mali the branches are woven into baskets.

Production and international trade *Pteleopsis habeensis* is only used locally.

Botany Straggling shrub or small, twisted tree with dense, rounded crown; bark fibrous, flaking off even in young branches, grey-brown, inner bark pale brown; branchlets slightly hairy, grey-brown. Leaves subopposite; petiole 1–4 mm long, hairy; blade ovate, c. 3–6 cm × 1.5–2.5 cm, base rounded or obtuse, apex obtuse or obtusely acuminate, purplish at the start of the dry season, hairy when young, later glabrous or slightly pubescent, pinnately veined with 5–7 pairs of only slightly prominent secondary veins merging near the margin, smaller veins reticulate. Inflorescence a pseudo-umbel 1.5–2 cm in diameter. Flowers whitish. Fruit c. 10 mm × 7 mm, slightly hairy, with 3 wings; pedicel 7–9 mm long, very thin.

Pteleopsis is a small genus of about 10 species, all in tropical Africa.

Ecology *Pteleopsis habeensis* occurs on sandstone, in general on gravelly slopes along watercourses. The habitat, although associated with stream beds, is very dry, as the soils are sandy and well-drained, and the species is never found in or near the actual streambed.

In Mali *Pteleopsis habeensis* forms low thickets with *Combretum micranthum* G.Don. In the Yankari Game Reserve in Nigeria it covers several square kilometres, and forms pure stands of coppice-like woodland of numerous thin stems, uniform in height and girth, forming a closed canopy 8–15 m high. In Nigeria it is apparently fire-tender and occurs either in places where it is protected from fire, such as on rocky hills and cliffs, or where it shades out the fuel-providing grasses. Although large herbivores use the vegetation as a shelter, they seem to avoid feeding on this species; it is deciduous and does not provide shade or feed during the dry season and the foliage is probably unpalatable, as is that of many *Combretaceae*. The dense leaf cover seems to allow only the growth of shade-loving plants below it.

Management *Pteleopsis habeensis* is only collected from the wild.

Genetic resources and breeding *Pteleopsis habeensis* is a typical relict species, known from a few localities only. It is classified as endangered in the IUCN Red list because of its small area of distribution and declining habitat and numbers. This is especially the case in

Ghana. In Nigeria, the largest area of *Pteleopsis habeensis* is in the well protected Yankari Game Reserve where the future of both the species and the exceptional vegetation type it forms, seems more secure. As a consequence, the IUCN conservation status might need reconsideration.

Prospects It is unlikely that *Pteleopsis habeensis* will retain its importance as a fibre plant, also because of its declining habitat and numbers.

Major references Aubréville, 1950; Burkill, 1985; Geerling, 1982; Geerling, 1984; Keay, 1954b.

Other references Afolayan & Ajayi, 2008; Hawthorne, 1990; Hawthorne, 1998; Hopkins & Stanfield, 1966; Poorter et al., 2004.

Authors L.P.A. Oyen

PYCREUS LANCEOLATUS (Poir.) C.B.Clarke

Protologue Consp. Fl. Afr. 5: 538 (1894).

Family Cyperaceae

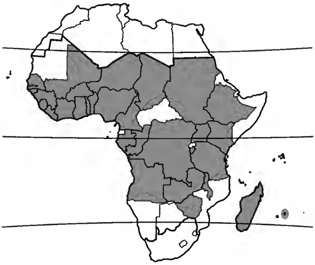
Chromosome number $2n = 42$

Synonyms *Cyperus lanceolatus* Poir. (1806), *Pycreus propinquus* Nees (1842).

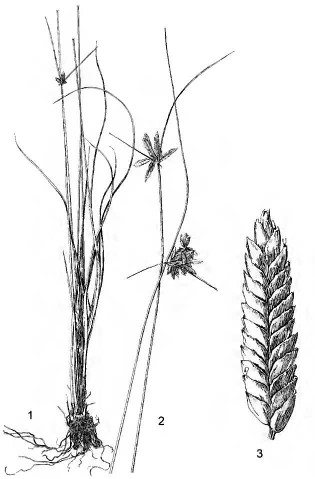
Vernacular names Epiphytic flatsedge, lance sedge (En).

Origin and geographic distribution *Pycreus lanceolatus* is widely distributed in tropical Africa, tropical America and the southern United States.

Uses In Madagascar the stems of *Pycreus lanceolatus* are used for plaiting.



Pycreus lanceolatus – wild



Pycreus lanceolatus – 1, flowering plant habit; 2, inflorescence; 3, spikelets.
Source: Flore analytique du Bénin

Botany Perennial, loosely tufted herb with a short rhizome or with distant stems arising from creeping stolons; stems up to 75 cm tall and 0.5–2 mm in diameter, 3-angled in cross-section, glabrous, with scales at the base. Leaves inserted in the lower part of the stem; sheath glabrous, dark brown; ligule membranous; blade linear, up to 40 cm × 4 mm, with scabrid margin and midvein (at least near the apex). Inflorescence a terminal, globose head-like anthela 1–4 cm in diameter, with usually many, tightly packed spikelets; bracts 2–3, leafy, spreading, up to 22 cm long. Spikelets sessile, linear-lanceolate, 5–28 mm × 2–4 mm, pale yellow-brown, many-flowered; glumes distichous, ovate, 2–3 mm long, lowermost ones smaller, obtuse at the apex, pale or golden brown, often with red-brown patches and a green midvein; flowers bisexual, stamens 1–3, ovary superior, 1-locular, stigmas 2. Fruit an obovate nutlet 1–1.5 mm × 0.5–1 mm, apiculate, biconvex, grey, red-brown or black, minutely papillose, 1-seeded.

In Senegal *Pycreus lanceolatus* flowers in August–December(–January).

Pycreus comprises c. 80 species, distributed in the tropical, subtropical and temperate regions of the world. *Pycreus intactus* (Vahl) J.Raynal (synonyms: *Cyperus intactus* Vahl, *Pycreus ferrugineus* (Poir.) C.B.Clarke) is a perennial herb with stems up to 65 cm tall, recorded from Senegal, Guinea Bissau, Madagascar, Réunion, Asia and the Americas. In Madagascar its stems are used for plaiting. The stems of *Pycreus rhizomatosus* C.B.Clarke (synonym: *Pycreus commersonii* (C.B.Clarke) Cherm.), endemic to Madagascar, are also used for plaiting. *Pycreus mundtii* Nees (synonym: *Cyperus mundtii* (Nees) Kunth) is a perennial, stoloniferous herb with stems up to 40(–60) cm tall, distributed throughout Africa and the Mediterranean region, and rare in tropical America. In experiments in the 1950s using the sulphate process the pulp yield of material from Zimbabwe was low and the pulp was wet and fairly weak. The stem is recorded to be unsuitable for thatching. *Pycreus mundtii* is a C_4 plant. In Madagascar it is a troublesome weed in rice fields.

Ecology *Pycreus lanceolatus* occurs from sea level up to 2100 m altitude on river banks, in marshes, wet grassland and other wet locations. It is a common weed in rice fields.

Management Natural reproduction of *Pycreus lanceolatus* is by seed and rhizomes.

Genetic resources and breeding In view of its wide distribution and common occurrence *Pycreus lanceolatus* seems not liable to genetic erosion.

Prospects *Pycreus lanceolatus* is only locally used for plaiting, and its importance is unlikely to increase.

Major references Akobundu & Agyakwa, 1998; Boiteau, Boiteau & Allorge-Boiteau, 1999; Burkill, 1985; Lye, 1997a; Vanden Berghen, 1988.

Other references Ball, Reznicek & Murray (Editors), 2003; Chittenden & Morton, 1955; Ellery, Ellery & Verhagen, 1992; Hoenselaar, Verdcourt & Beentje, 2010; Hooper & Napper, 1972; Lye, 1981; Michelan & Vanzela, 2009; Nutsugah et al., 2003; Scholz & Scholz, 1983; Watt & Breyer-Brandwijk, 1962.

Sources of illustration Akoègninou, van der Burg & van der Maesen, 2006.

Authors M. Brink

RAPHIA FARINIFERA (Gaertn.) Hyl.

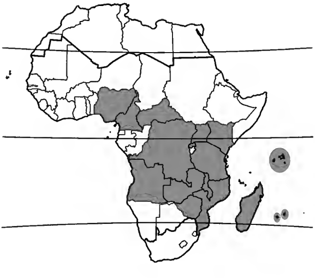
Protologue Lustgården 31–32: 88 (1952).
Family Arecaceae (Palmae)
Chromosome number $2n = 32$

Synonyms *Raphia ruffia* (Jacq.) Mart. (1838), *Raphia pedunculata* P.Beauv. (1806), *Raphia kirkii* Engl. ex Becc. (1910).

Vernacular names Madagascar raphia palm, Bamenda raphia, East African wine palm, raffia palm (En). Raphia, palmier à raffia, palmier de Mayotte (Fr). Mwale, muwala, rutoro (Sw).

Origin and geographic distribution *Raphia farinifera* is distributed throughout the southern part of tropical Africa. It is frequently cultivated, for instance in Nigeria, Madagascar, the Seychelles, Réunion, India, the United States and the Lesser Antilles, and it has often naturalised.

Uses Raffia fibre obtained from the upper surface of young leaflets is used worldwide as tying material for horticulture and handicrafts. In tropical Africa it is locally used for tying and for making a wide range of products, including mats, baskets, hats, wallets, shoes, bags, fishing nets, hammocks, curtains and textiles. The leaves are used for thatching, and the leaflets for plaiting. In Madagascar the midveins of the leaflets are used for making fishing nets and a range of articles for domestic use. The petiole and rachis are used for furniture, house construction, fences and ladders, and as poles. The rachis is locally made into sweeping-brushes. In Madagascar the dry petiole is cut into pieces of 40 cm long, which are used as floats for fishing nets. In Uganda strips from the petiole are used for basket weaving.



Raphia farinifera – wild and planted

The stems of the palm are a source of starch. The young terminal bud ('palm cabbage') is eaten as a vegetable. The palm is tapped for sap to be fermented into palm wine. The wine is also distilled into a strong alcoholic liquor and can also be used as bakers' yeast. The fruit and seeds are eaten, and the fruit pulp is fermented into an alcoholic drink. Oil from the mesocarp and seed is used as food ('raphia butter') and for the production of soap and stearin. The shells of the fruits are made into snuffboxes or buttons, and the fruits and seeds are used for decoration. A wax obtained from the lower surface of the leaflets has been used for floor and shoe polishes and for making candles. *Raphia farinifera* is planted as a wayside and ornamental tree.

In Madagascar the root is used against toothache, fibres from the leaf sheath are used for the treatment of digestive disorders, and a liquor obtained from the inflorescence is a drink as well as a laxative. In Mauritius a decoction of the fruit pulp is used against dysentery, and an infusion of the fruit is said to attenuate haemorrhages.

Production and international trade Most of the raffia of international commerce is produced in Madagascar from *Raphia farinifera*. In the 1950s c. 5000 t of raffia fibre was annually exported from Madagascar, but in the 1980s and 1990s the average annual exports were only around 2000 t. Oil from the mesocarp has been exported to the European market as 'bamboo oil'.

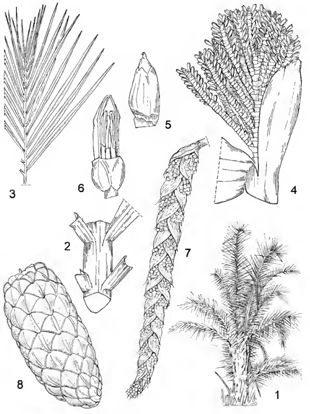
Properties Raffia fibre is soft but strong. It is well suited to horticultural purposes, because it is supple and durable and it does not have sharp edges which might damage tender plant parts. The material is easy to prepare to desired widths as it is readily split. It is also easily dyed, making it suitable for the production of fancy articles. The average tensile strength of raffia fibre from Madagascar is 500 N/mm^2. The rachis is lightweight, easy to cut, strong and durable, making it very suitable for construction and furniture.

The fruit pulp contains about 24% oil, the seeds only 1%. The major fatty acids in seed oil from Madagascar are palmitic acid, oleic acid and linoleic acid. The main sterol is β-sitosterol. The fruit pulp has shown antibacterial activity against *Staphylococcus aureus*, but not against the Gram negative bacteria *Escherichia coli*, *Pseudomonas aeruginosa*, *Salmonella typhi* bacteria; it also had no activity against the fungi *Candida albicans* and *Aspergillus niger*.

A crude extract of the stem bark caused significant mortality in vitro of adults and microfilariae of *Onchocerca volvulus*, which causes river blindness.

Adulterations and substitutes Raffia fibre is also obtained from *Raphia hookeri* G.Mann & H.Wendl., occurring in West and Central Africa. The fibre faces competition from synthetic substitutes. *Raphia hookeri* as well as various other *Raphia* species are locally used like *Raphia farinifera* as a source of weaving material, construction material, palm heart, palm wine and oil.

Description Monoecious, massive, clustering (in Madagascar often solitary) tree up to 25 m tall; trunk up to 10 m tall and 100 cm in diameter, the lower part with pronounced leaf scars, some remains of rotten leaf sheaths, and adventitious roots, the upper part covered with leaf-bases. Leaves pinnate, erect or slightly spreading, up to 20 m long, sheathing at the base, shiny above, waxy below; sheath unarmed, splitting opposite the petiole, sheath and petiole together c. 1.5 m long; petiole 12–



Raphia farinifera – 1, habit; 2, mid-section of leaf; 3, leaf apex; 4, inflorescence branch; 5, female flower; 6, male flower (one petal removed); 7, infructescence branch; 8, fruit.
Source: PROSEA

20 cm in diameter, rounded in cross-section, unarmed; rachis unarmed, orange-brown or almost crimson, with 2 lateral grooves near the base; leaflets up to 150 on each side of the rachis, inserted in 2 planes, linear, stiff, up to 200 cm × 8 cm, single-fold, lower surface white waxy, upper surface sparsely waxy, margins and main veins with yellowish spines up to 4 mm long, main veins somewhat reddish. Inflorescence axillary, pendulous, up to 4(–6) m × 35 cm, branched to 2 orders; primary inflorescence bract c. 30 cm × 20 cm, tubular, partly enclosing the first and second order branches, peduncular bract 18 cm × 8 cm, tubular for 11 cm; second order prophylls 9 cm long; first order branches with 13–32 rachillae, up to 30 cm × 2.5 cm; rachilla up to 15 cm × 1.5 cm. Flowers unisexual; male flowers at apex of inflorescence branchlets, female flowers at base; male flowers up to 12 mm × 2 mm, enclosed in a bract, calyx with tube 4–5 mm long and 3 small lobes, corolla with basal tube 2–3 mm long and 3 lobes up to 10 mm × 2.5 mm, with segments slightly thickened near the tip, stamens 6(–9), inserted at the mouth of the corolla tube, filaments 2–3 mm long; female flowers enclosed in 2 bracts, calyx tubular, up to 8 mm long, corolla much shorter than calyx, with basal tube up to 2 mm long and lobes c. 3 mm long, staminodes 6, inconspicuous, ovary superior, 3-celled. Fruit ovoid to ellipsoid, 4.5–11 cm × 3–6 cm, with a beak up to 5 mm long, covered with scales in 12–13 rows, usually 1-seeded; scales convex, reflexed, up to 20 mm × 26 mm, bright orange-brown; mesocarp golden yellow. Seed ovoid to ellipsoid, 3–6 cm × 3–4.5 cm; mesocarp oily; endosperm sparsely to densely ruminate.

Other botanical information *Raphia* comprises c. 20 species, mostly African, predominantly found in swampy areas. One species, *Raphia taedigera* (Mart.) Mart., is found in tropical America. *Raphia farinifera* in East Africa has often been referred to as *Raphia monbuttorum* Drude.

Growth and development *Raphia* species have monocarpic stems, i.e. they flower and fruit only once, followed by death. Inflorescences are produced more or less simultaneously in the axils of the most distal leaves. Tapping for wine may damage the developing inflorescence, making flowering impossible and accelerating death. *Raphia farinifera* in Madagascar takes 20–25 years from seed to flowering and 5–6 years from flowering to ripe fruit, with all fruits maturing in the same year.

Ecology In its natural distribution area, *Raphia farinifera* is widespread in gallery forest, freshwater swamp-forest and other moist locations, up to 2500 m altitude. In Madagascar it is common near villages at the edge of water courses, at 50–1000 m altitude.

Propagation and planting *Raphia farinifera* is propagated by seed. Germination is slow, unless the outer layers of the seed are removed and the root is exposed. In Madagascar seeds have been reported to germinate after 4–5 months, and to be ready for planting out in the field at 1 year after sowing. Seedlings may also be collected from the wild and raised in a nursery before being planted out in the field. A normal spacing is 12 m × 12 m. Propagation by tissue culture techniques may offer potential for *Raphia*.

Management Plantations are weeded during the first years after planting.

Diseases and pests The rhinoceros beetle (*Oryctes rhinoceros*) attacks *Raphia farinifera* in Mauritius.

Harvesting In Madagascar harvesting of leaves for raffia fibre usually takes place at the end of the rainy season, from trees at least 10 years old. Normally 2–3 leaves per year are harvested from each palm.

Yield In Madagascar the yield of dry raffia fibre is about 3% of the fresh leaf weight.

Handling after harvest To obtain raffia fibre in Madagascar, the harvested leaves are transported to a shaded area, where they are processed immediately. The leaflets are removed from the rachis and the upper epidermis is separated from the rest of the leaflet. Sometimes the midvein is removed before the epidermis is pulled off, leaving two half leaflets. After the epidermis has been removed, it is dried, which should be done properly to obtain fibre of good quality. To obtain oil, the fruits are crushed, and after adding water, boiling and cooling, the floating oil is skimmed off.

Genetic resources In the 1950s the area covered by natural populations of *Raphia farinifera* in Madagascar was estimated at 50,000 ha. Although the species is not considered threatened, populations in Madagascar have declined due to over-exploitation, bush fires and conversion of their habitat into rice fields. No germplasm collections of *Raphia* are known.

Breeding No breeding programmes of *Raphia* are known.

Prospects *Raphia farinifera* is the main source of raffia fibre, which, despite the availability of synthetic substitutes, is still used worldwide as tying material for horticulture and handicrafts. Furthermore, *Raphia farinifera* is a very useful local source of a range of products, including construction material, palm wine, oil and traditional medicines. Its importance in the international market is unlikely to decline, although in Madagascar, the main producer, natural populations of *Raphia farinifera* are decreasing, and there is need to prevent over-explotation, protect the habitat and to encourage its planting.

Major references Boiteau, Boiteau & Allorge-Boiteau, 1999; Dransfield, 1986; Dransfield & Beentje, 1995; Gaydou et al., 1980; IPK, undated; Katende, Birnie & Tengnäs, 1995; Medina, 1959; Ruffo, Birnie & Tengnäs, 2002; Rustiami & Brink, 2003; Sandy & Bacon, 2001.

Other references Adjanohoun et al., 1983b; Bedford, 1980; Beentje, 1994b; Byg & Balslev, 2001a; Coates Palgrave, 1983; Guglielmo, Pavone & Salmeri, 2009; Gurib-Fakim & Brendler, 2004; Gurib-Fakim, Guého & Bissoondoyal, 1995; Jelager, Gurib-Fakim & Adsersen, 1998; Jumelle, 1945; Letouzey, 1978; Llamas, 2003; Moore & Guého, 1984; Mouranche, 1955; Muhwezi, Cunningham & Bukenya-Ziraba, 2009; Razafindratovo Ndriana, 2006; Robinson & Johnson, 1953; Titanji et al., 1987; USDA, ARS & National Genetic Resources Program, 2001; Williamson, 1955.

Sources of illustration Rustiami & Brink, 2003.

Authors L. Jimu

RAPHIA HOOKERI G.Mann & H.Wendl.

Protologue Trans. Linn. Soc. 24: 438 (1864).

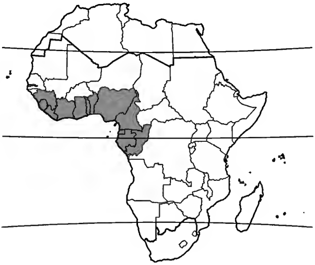
Family Arecaceae (Palmae)

Chromosome number $2n = 28$

Synonyms *Raphia gigantea* A.Chev. (1932), *Raphia sassandrensis* A.Chev. (1932).

Vernacular names Raphia palm, wine palm, Ivory Coast raphia palm (En). Raphia (Fr). Ráfia (Po). Mwale (Sw).

Origin and geographic distribution *Raphia hookeri* is found from Gambia through the Guinea forest zone of West Africa to Cameroon, Gabon and Congo and possibly to DR Congo and Angola. It is occasionally cultivated, e.g. in Nigeria. Outside Africa it is grown in India, Peninsular Malaysia and Singapore.



Raphia hookeri – wild

Uses *Raphia hookeri* yields two valuable types of fibre: piassava or bass, and raffia. The very strong piassava fibre is obtained from the petiole and leaf sheath and is used locally to make weather-resistant coarse ropes, belts for climbing oil-palms and brushes. It is exported for the production of hard brooms and brushes. Piassava fibre is used to make exceptionally strong paper. It can also be used to produce very fine-textured charcoal, much favoured for the manufacture of home-made gunpowder. The soft but strong raffia fibre has also been considered a potential source of pulp for paper production. It is obtained by pulling off ribbon-like strips from the upper surface of the leaflets of young unfolding leaves and is used to make mats, hats, baskets, bags, ropes, hammocks, ceremonial costumes, etc. It may be woven into cloth. In Europe it is used as tying material for horticulture and handicrafts. The leaves of *Raphia hookeri*, often split lengthwise, are used for thatching, though they last only 1 year. They are also used to make mats, baskets and other articles of wickerwork, and are used for hut-walls and fences. The midribs and petioles of the leaves ('raffia bamboo' or 'bamboo') are used for poles, rafters, ladders, furniture and cross-bearers in canoes. Split lengthwise they are used to make screens.

Sap tapped from the stem when the tree nears the flowering stage ferments rapidly into palm wine ('mimbo'), a very popular drink throughout West Africa. In Nigeria it is bottled for commercial purposes, although there is a risk that bottles can explode due to continuing fermentation. The wine is distilled into a strong alcoholic liquor and can also be used as bakers' yeast. The young terminal bud or 'palm cabbage' is eaten as a vegetable.

The raw fruit is sometimes used to flavour food, but elsewhere it is considered poisonous, and it is crushed for use as fish poison. Boiled or roasted kernels are sometimes eaten.

In Ghana the leaf juice is used for the treatment of laryngitis and lactation failure. Boiled fruits are eaten in Nigeria. The oily mesocarp is used in traditional medicine for its laxative and stomachic properties and as a liniment for pains. The ash of burnt and ground roots mixed with palm oil is instilled into the ear for the treatment of otitis. Larvae of the rhinoceros beetle (*Oryctes* sp.), found in rotting stems, are collected and eaten.

Production and international trade *Raphia hookeri* is the main piassava yielding *Raphia* species. Its piassava has been exported to temperate countries (mainly Europe) for the production of brooms and brushes since the end of the 19th Century, when the supply of South American piassava (from *Attalea funifera* Mart. and *Leopoldinia piassaba* Wallace), used in Europe for brooms since the middle of the 19th Century, could no longer meet demand. The trade reached its peak in the 1950s and 1960s (7000 t exported from Sierra Leone, the main exporting country, in 1964; 5300 t from Nigeria in 1966; there was also trade from Guinea), after which it declined with the advent of plastic brooms. The particular qualities of African piassava for broom-making are such that it still enters the international market. The main types of African piassava fibre in trade are 'Sherbro', 'Sulima' and 'Calabar' ('Opobo'). Sherbro and Sulima are obtained from the petiole, the former from *Raphia hookeri* and the latter from *Raphia palma-pinus* (Gaertn.) Hutch., often with an admixture of *Raphia hookeri* fibres, whereas Calabar is extracted from the leaf sheath of *Raphia hookeri*. The leaf sheaths of *Raphia palma-pinus* are rather short and do not yield high quality fibre. Most of the raffia of commerce is produced in Madagascar from *Raphia farinifera* (Gaertn.) Hyl.

Although palm wine is the main product of *Raphia hookeri* in several regions, no production data are available. The wine is mainly used and traded locally. Distilled palm wine is also mainly traded locally although there is some trade between neighbouring countries.

Properties Piassava fibre is water resistant, hard-wearing, and has the right balance between stiffness and elasticity to give a firm stroke to a broom and sufficient spring action to make the broom self-cleaning. The best piassava fibre is cylindrical with a firm wall and a soft core and a diameter of 1–1.5 mm. It is obtained from the sides ('wings') of the petiole, whereas fibre from the upper and lower surfaces is of only reasonable quality. Fibres near the central flattened ridge are woody and brittle. The central core of the petiole gives a soft fibre ('straw' or 'piassava tow') which may be used as a substitute for coir from coconut. The best quality Calabar fibre is obtained from the sides of the leaf sheath, i.e. not near the suture and not near the midrib. Fibre obtained from the midrib of the leaf sheath is softer and more pliable making it suitable for plaiting ropes. Calabar piassava is stiffer than Sherbro and Sulima and tends to be black, whereas Sherbro and Sulima are pale at harvest, turning darker during retting. Mature leaves yield higher quality piassava fibre than younger leaves.

Raffia fibre is well suited to horticultural purposes, because it is supple and durable and it does not have sharp edges which might damage tender plant parts. It is easily dyed, making it suitable for the production of fancy articles. *Raphia hookeri* yields high-quality raffia with a high tenacity.

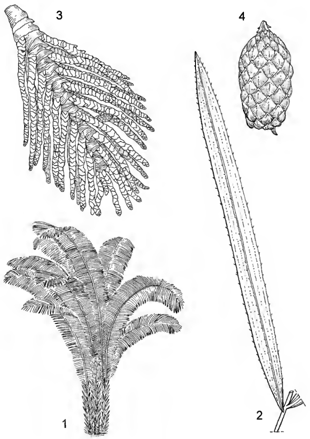
Both the stem and the petiole of *Raphia hookeri* are suitable as raw material for the paper industry. Stem fibres are mostly thick walled and, on average, 2.4 mm long and 30 μm wide. The width is rather variable, ranging from 17–46 μm. The fibres of the petioles are on average 1.7 mm long and 18 μm (10–27 μm) wide. Many fibres have scalloped walls. The pitted vessel elements of the stem are few in number but very large, up to 5 mm long and 350 μm wide, whereas those of the petioles are generally smaller. Pulp from *Raphia hookeri* also contains rounded, thick-walled parenchyma cells and spherical silica bodies. Dry stems consist of about 74% fibre, 25% parenchyma, and 1% vessel elements.

Palm wine obtained from *Raphia hookeri* is attractively milky-white in colour, but is weaker and less sought after than that from oil palm. When fresh, the sap tastes like ginger beer. The alcohol content of the sap increases from less than 2% to about 5% during the first 8 days of tapping, remaining constant thereafter. *Leuconostoc* and *Lactobacillus* bacteria are present in the early stages of fermentation, while the yeast *Saccharomyces cerevisiae* is mainly responsible for the alcohol fermentation.

The major fatty acids in mesocarp oil and seed oil are linoleic acid, palmitic acid and oleic acid. Mesocarp oil from *Raphia hookeri* resembles that from oil palm in colour, taste, odour and chemical composition, except that it contains more linoleic acid, giving it a higher unsaturated acid content. The fruit has been reported to contain toxic and antinutritional factors, such as hydrocyanic acid, tannins, oxalate and phytic acid. Cooking reduces the levels of these. The kernel contains per 100 g: moisture 11 g, energy 1365 kJ (326 kcal), protein 8 g, fat 1 g, carbohydrates 63 g, fibre 8 g, ash 9 g, Ca 1519 mg and P 277 mg (Leung, Busson & Jardin, 1968). In bioassays the aqueous and butanol fractions of the methanolic extract of *Raphia hookeri* mesocarp showed cytotoxicity against brine shrimp, and the butanol fraction also against mosquito larvae and 5-day old tadpoles.

Adulterations and substitutes *Raphia* species used for similar purposes as *Raphia hookeri* include *Raphia africana* Otedoh, *Raphia farinifera*, *Raphia mambillensis* Otedoh, *Raphia palma-pinus*, *Raphia regalis* Becc., *Raphia sudanica* A.Chev. and *Raphia vinifera*. The original sources of piassava fibre are *Attalea funifera* ('Bahia piassava' or 'Bahia bass') and *Leopoldinia piassaba* ('Para piassava' or 'Monkey bass'), both from Brazil.

Description Monoecious tree, trunk up to 10 m tall and 30 cm in diameter, usually single, occasionally with 1–4 suckers; upper part of trunk with blackish fibres (marcescent leaf-bases). Leaves arranged spirally, pinnate, up to 12 m long, erect, dark green and shining above, waxy and glaucous below; sheath 3–4 m long, unarmed, splitting opposite the petiole; petiole 3–4 m long; leaflets 1–1.5 m × 4–5 cm, about 200 on each side of the rachis, terminal segments gradually narrowing to a fine point and having spines on upper side of midrib and on margins. Inflorescence axillary, pendulous, 2.5 m or more long, branched to 2 orders, compressed-cylindrical, with crowded branches; branches bearing many curved ultimate branchlets in 4 rows but mostly compressed into one plane; branchlets 15–23 cm long, rigid; branches and branchlets with short-tubular, truncate bracts at base. Flowers unisexual; male flowers at apex of inflorescence branchlets, female flowers at base, 3-merous; male flowers 1.5–2.5 cm long, with 1 bracteole slightly longer than thick, calyx with blunt lobes, corolla much longer than calyx, curved, with segments thickened near the tip, stamens (15–)18–22(–24), with erect, linear anthers; female flowers larger than male, with 2 bracteoles, calyx as in male, corolla about as long as calyx, with acuminate segments thickened near tip, staminodes 12–15, ovary superior, 3-celled, stigma sessile, recurved, subulate. Fruit a 1-seeded berry, inversely conical or ellipsoid, 6–12 cm × 4–5 cm, with stout beak 1–1.5 cm long, more or less obliquely tipped, covered with scales in (11–)12(–15) vertical rows; scales convex, slightly less broad than long, narrowly furrowed, reddish brown or pale yellowish brown with darker point, obtuse at the base, almost entire. Seed 6–7.5 cm × 3–3.5 cm, oblong, irregularly grooved; albumen narrowly ruminate. Seedling with hypogeal germination, with tap root and some adventitious roots; first 3–4 leaves strongly reduced and irregularly incised, subsequent leaf 50–100 cm long and with about 12 leaflets at each side of the rachis.



Raphia hookeri – 1, plant habit; 2, leaflet; 3, inflorescence; 4, fruit.
Redrawn and adapted by W. Wessel-Brand

Other botanical information *Raphia* comprises c. 20 species, mostly African, predominantly found in swampy areas. One species, *Raphia taedigera* (Mart.) Mart., is found in tropical America. Three varieties of *Raphia hookeri* have been distinguished: var. *hookeri*, var. *planifolia* Otedoh and var. *rubrifolia*

Otedoh. Locally, different forms of *Raphia hookeri* are recognized.

Anatomy The hypodermis of *Raphia hookeri* leaflets consists of thick fibres arranged in a continuous ribbon-like layer with no discontinuities. In *Raphia vinifera* the fibres are not arranged in a ribbon-like layer, but are discontinuous, resulting in less tenacity.

In both the stem and petiole the vascular system consists of bundles which are scattered throughout the ground tissue and the cortex is very narrow or non-existent. The peripheral vascular bundles of the central cylinder are congested and have a well-developed fibrous sheath. The vascular bundles are separated by parenchyma. In the inner part of the central cylinder, the vascular bundles are more diffuse than in the periphery. Stem fibres are more numerous than in the petiole, partly because the vascular bundles are closer and partly because the fibrous bundle sheaths are thicker in the central parts.

Growth and development *Raphia hookeri* develops in accordance with Tomlinson's growth model. When young the main stem forms a few basal suckers. *Raphia* species have monocarpic stems, i.e. they flower and fruit only once, followed by death. Inflorescences are produced more or less simultaneously in the axils of the most distal leaves. Tapping for wine may damage the developing inflorescence, making flowering impossible and accelerating death. The time from planting to flowering in *Raphia hookeri* is 3–7 years. In Nigeria, *Raphia hookeri* flowers in May. The pericarp reaches maturity at 24–30 months, the seed matures in about 30–33 months. Lipid accumulation in the pericarp mainly occurs between 30–36 months after pollination. Ground squirrels, bats and birds feed on the mesocarp.

Ecology *Raphia hookeri* occurs in freshwater swamps and on river banks in the Guinean Zone of West and Central Africa. It generally does not tolerate saline conditions; near the Guinea coast it is replaced by *Raphia palma-pinus*. In some places (e.g. southern Benin and south-eastern Nigeria) human activity (cutting of dicotyledonous trees, planting of *Raphia hookeri*) has turned natural swamp vegetation into 'rafiales', in which *Raphia hookeri* is the dominant species. The soils of Nigerian freshwater swamps are light textured and generally acidic.

Propagation and planting Managed stands of *Raphia hookeri* are mostly left to rejuvenate naturally by seed. In Nigeria, selected trees are left untapped for this purpose. Occasionally, *Raphia hookeri* is propagated from seed. The 1000-seed weight is about 25 kg. The germination period may range from 1–24 months, and the germination rate from 30–60%. Young plants are easily transplanted. In nurseries, a spacing of 30 cm × 30 cm is recommended. It has been claimed that seeds should be sown ventral side upwards, because the embryo is located on this side, but research has shown that seed orientation does not influence germination or seedling growth.

In Nigeria, *Raphia hookeri* sometimes serves as support for yams. In Benin, tomatoes, cassava, sugar cane, red pepper and other crops are sometimes grown on earth ridges in *Raphia hookeri* swamps.

Management In West Africa, *Raphia hookeri* is exploited from natural stands, but it is also planted and tended on upland farms. Suckers are often removed by farmers to promote growth of the main stem.

Diseases and pests *Raphia hookeri* in Nigeria is affected by seedling blight, caused by *Glomerella cingulata*. Symptoms are transparent yellow circular spots appearing on the youngest fully expanded leaves, later becoming necrotic and coalescing. The infection spreads from the tip to the base of the leaflet and may lead to leaflet shedding. Severely infected seedlings may die. Fruit rot, caused by *Thielaviopsis paradoxa* (synonym: *Chalara paradoxa*), also occurs in Nigeria, causing dark brown rot of the mesocarp. It is a weak pathogen entering fruit via wounds, sometimes killing the embryo, and leading to loss of planting material. The aphid *Cerataphis palmae* may cause considerable damage, e.g. in Nigeria.

Harvesting Because palm wine from *Raphia hookeri* is highly prized, cultivators are reluctant to diminish plant vigour by cutting leaves for their fibre. However, dying leaves can be harvested for piassava with little effect on wine yields. Removing the leaf sheaths requires considerable leverage, and is usually a team effort. Stout poles, flattened at the end, are inserted into the suture of the lowest leaf sheath and the stem, and the sheath is levered away, while additional weight is applied to the petiole. As it is easier to remove the leaf sheaths from a fallen trunk, palms are often felled after tapping and before fibre harvesting. In Nigeria, external fibres covering the trunk are sometimes set on fire, after which the tree is felled with an axe, the leaves and lower trunk are cut off with a cutlass, and the leaf stalks are cut and removed from the base to the crown successively.

Tapping for palm wine begins when the first small leaf (2–3 m long) subtending an inflorescence appears. A cavity is cut in the stem just below the growing point and the resulting sap is collected in a calabash. When sap flow diminishes, the hole is enlarged until it is about 50 cm × 20 cm. *Raphia* can usually be tapped for 18–25 days before the tree dies. Unlike oil palm, *Raphia* palms are rarely felled before tapping. For maximum oil yields, the fruits should be harvested 36–42 months after pollination.

Yield No data on fibre yield are available. Palm wine yields of 870 l have been recorded from a single tree in a 2-month period from cutting to death, but average yields are about 100 l per palm.

Handling after harvest Piassava fibre extraction is different for leaf sheaths and petioles. The tissue of older leaf sheaths is already moribund and has started to soften, and the outer thicker and more brittle fibres can be stripped off or, in some areas, are removed by burning the trunk. Starting from the outer 'wings', the useful fibres are sequentially stripped by hand. When removal of the fibres is difficult, usually in younger leaf sheaths, the tissue is beaten with a stick or the trunk is left exposed to the elements until the tissue has softened. The traditional practice of fibre extraction from the petiole, with its more solid tissue and hard epidermis, is to split the petiole along the longitudinal axis into 3 or 4 splits, which are tied into bundles and immersed in water. The retting period varies from a few weeks to 2–3 months. After retting, the fibres can be stripped off relatively easily. Retting influences the appearance of the fibres. Sherbro and Sulima piassava, somewhat pale coloured at harvest, turn brownish on retting. Material retted in fresh running water tends to be pale brown, whereas material retted in stagnant swamp pools develops a reddish brown tinge, which is attractive and leads to higher prices. The extracted fibres still have a coating of decomposing background tissue which has to be removed. In the case of Calabar piassava this coating is stripped by drawing the fibre through a cleft cut into a stick or palm petiole. In the case of Sherbro and Sulima, the retted strips are usually flogged over and drawn through a comb of pointed sticks. Fibres may also be separated and cleaned by hand. The cleanliness of the fibre has a large impact on quality and market value. Cleaned fibres may be spread out to dry in the sun for a few days. Further drying may occur under the eaves of houses or above fireplaces. Fibres which are not properly dried become mouldy and brittle and can be a fire hazard in warehouses and ships. Fibre length is an important attribute as long fibres provide more opportunities for further processing. It is also important that bundles consist of fibres of uniform length. High quality Sherbro and Sulima fibres show little variation in length and are about 1.5 m long. Although shorter fibres are acceptable, they should not be shorter than 25–30 cm. The Sherbro and Sulima fibres are normally packed in bundles of 25 kg. Calabar fibres are more variable in length and require sorting into bundles of uniform length – a tedious and time-consuming task. Traditionally, bundles of fibres of differing lengths are transported to local markets, where they are weighed and priced. The buyer then mixes fibres from different sources before trimming and tying them into uniform bundles of 70–100 cm diameter.

Palm wine from *Raphia hookeri* is mostly consumed fresh, but can be distilled to make a strong alcoholic liquor.

Genetic resources No germplasm collections of *Raphia hookeri* are known. *Raphia hookeri* is not threatened with extinction as it occurs over a very large area and is widely protected by farmers.

Prospects Locally, *Raphia hookeri* will remain an important multipurpose palm, yielding various types of fibres, highly valued palm wine and a range of other products. Its importance in international trade as a source of African piassava fibre has declined sharply following the advent of plastic substitutes, but there is still demand for natural brush-fibres. This demand may even increase in the future as environmentally friendly, traditional products gain popularity.

Major references Burkill, 1997; Edem, Eka & Ifon, 1984; Ilvessalo-Pfäffli, 1995; Kirby, 1963; Opute, 1978; Otedoh, 1973; Profizi, 1986a; Russell, 1965; Russell, 1968; Tuley, 1994.

Other references Boon & Ahenkan, 2008; de Koning, 1983; de Souza, 1982; Enobakhare, 1994; Faparusi, 1981; IPK, undated; Iremiren & Onwubuya, 1985; Irvine, 1961; Leung, Busson & Jardin, 1968; Ndon, 1985; Neuwinger, 1998; Obuotor & Onajobi, 2000; Ogbuagu, 2008; Oruade-Dimaro, 1987; Oruade-Dimaro &

Ekundayo, 1992; Otedoh, 1974; Profizi, 1988; Purseglove, 1972; Pyykkö, 1985; Steinkraus (Editor), 1996.

Sources of illustration de Kerchove de Denterghem, 1878; Hawthorne, 1990; Russell, 1965.

Authors M. Brink

RAPHIA PALMA-PINUS (Gaertn.) Hutch.

Protologue Fl. W. trop. Afr. 2: 387 (1936).

Family Arecaceae (Palmae)

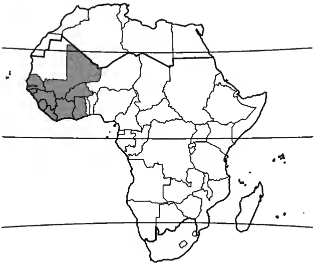
Synonyms *Raphia gracilis* Becc. (1910).

Vernacular names Thatch palm (En).

Origin and geographic distribution *Raphia palma-pinus* is distributed in West Africa, from Senegal and Gambia eastwards to Ghana

Uses Piassava fibre, mainly obtained from the petiole and leaf sheath of *Raphia hookeri* G.Mann & H.Wendl. and the petiole of *Raphia palma-pinus*, is used locally for making weather-resistant coarse ropes, belts for climbing oil-palms, and brushes, and is exported for the production of hard brooms and brushes. Piassava fibre is also used to make exceptionally strong paper. The leaves of *Raphia palma-pinus* are commonly used for thatching. The petiole and rachis are used as poles for making furniture items, such as chairs and beds, and in construction. The pith of the petiole and rachis is made into mats. In Senegal the fruits are considered a strong poison.

Production and international trade African piassava from *Raphia* spp. has been exported to temperate countries (mainly Europe) for the production of brooms and brushes since the end of the 19th Century, when the supply of South American piassava (from *Attalea funifera* Mart. and *Leopoldinia piassaba* Wallace), used in Europe for brooms since the middle of the 19th Century, could no longer meet demand. The trade reached its peak in the 1950s and 1960s (7000 t exported from Sierra Leone, the main exporting country, in 1964; 5300 t from Nigeria in 1966; there was also trade from Guinea), after which it declined with the advent of plastic brooms. The particular qualities of African piassava for broom-making are such that it still enters the international market. The main types of African piassava fibre in trade are 'Sherbro', 'Sulima' and 'Calabar' ('Opobo'). Sherbro and Sulima are obtained from the petiole, the former from *Raphia hookeri* and the latter from *Raphia palma-pinus*, often with an admixture of *Raphia hookeri* fibres, whereas Calabar is extracted from the leaf sheath of *Raphia hookeri*. The sheath of *Raphia palma-pinus* is too short for extraction of sufficiently long fibre. Most of the raffia fibre of commerce is produced in Madagascar from *Raphia farinifera* (Gaertn.) Hyl.



Raphia palma-pinus – wild

Properties Piassava fibre is water resistant, hard-wearing, and has the right balance between stiffness and elasticity to give a firm stroke to a broom and sufficient spring action to make the broom self-cleaning. The best piassava fibre is cylindrical with a firm wall and a soft core and a diameter of 1–1.5 mm. It is obtained from the sides ('wings') of the petiole, whereas fibre from the upper and lower surfaces is of only reasonable quality. Mature leaves yield higher quality piassava fibre than younger leaves.

Botany Monoecious tree, often clustering, with a trunk usualy 1–3 m tall, sometimes more, and covered with persistent leaf-bases. Leaves pinnate, 2–4(–8) m long, sheathing at the base; sheath short; petiole 0.5–1(–2.5) m long, channeled above, rounded below, smooth; rachis unarmed; leaflets linear-lanceolate, 50–80 cm × 2–4 cm, single-fold, acuminate at the apex, green-yellow, not shiny, lower surface waxy, margins and main veins with spines. Inflorescence axillary, pendulous, branched to 2 orders; flowering second order branches lax, rounded, 5–10(–20) cm long, with flowers in 4 ranks. Flowers unisexual; male flowers with tubular calyx with lobes half as long as tube, corolla lobes elliptical, stamens (8–)9–12, inserted on the corolla, free to the base; female flowers with tubular calyx, corolla campanulate, c. 12 mm long, with 3 lobes, staminodes 8, ovary superior, 3-celled, stigma sessile. Fruit ovoid to ellipsoid, (5–)8–9.5 cm × 3–4 cm, with a beak c. 5 mm long, covered with scales in 8–9 rows, 1-seeded; scales emarginate, fimbriate.

Raphia species have monocarpic stems, i.e. they flower and fruit only once, followed by death.

Raphia comprises c. 20 species, mostly African, predominantly found in swampy areas. One species, *Raphia taedigera* (Mart.) Mart., is found in tropical America.

Raphia gentiliana De Wild. (synonym: *Raphia gilletii* (De Wild.) Becc.) occurs in the Central African Republic and DR Congo. The leaves are used for thatching, fibres from the rachis are used for making mats, bags, textiles and carpets, and the rachis and petiole are used for construction, furniture, beehives and toys. The tree is tapped for palm wine, and the apical bud is eaten as a vegetable. A leaf decoction is taken against asthenia.

Raphia laurentii De Wild. is a palm with a stout trunk up to 6 m tall, occurring in the Central African Republic, DR Congo and Angola. Its leaves are used for thatching. It is also recorded to yield piassava and raphia fibre. The tree is tapped for palm wine. The fruit pulp yields c. 38% oil, which is used in food and as a protective and disinfectant skin ointment in traditional medicine. The main fatty acids in the oil are palmitic acid, linoleic acid and oleic acid.

Raphia regalis Becc. is a massive, stemless or almost stemless palm with leaves up to 25 m long, the largest leaves known in the plant kingdom. It occurrs in upland forest in Nigeria, Cameroon, Equatorial Guinea, Gabon, Congo and Cabinda (Angola). The leaves are used for thatching and mat making, and provide pulp for paper making. The palm is tapped for palm wine. In Gabon unspecified plant parts are used against fever and worms. *Raphia regalis* is classified as vulnerable in the IUCN Red list, due to its fragmented occurrence and decline of its habitat.

Raphia sese De Wild. is a palm with a trunk up to 11 m tall and up to 50 cm in diameter, occurring in Congo and DR Congo. The leaves are used for thatching, and the rachis is made into furniture, mats and arrows. Sap from the stem is fermented into palm wine. The fruit pulp yields 44% oil, which is used like that of *Raphia laurentii* in food and as a protective and disinfectant skin ointment in traditional medicine. The main fatty acids in the oil are palmitic acid, linoleic acid and oleic acid.

Ecology *Raphia palma-pinus* occurs in thickets in swamps with fresh or slightly brackish water, often in swamps behind mangrove areas. It can form substantial populations.

Management *Raphia* palms are generally propagated by seed. The traditional practice of piassava fibre extraction from the petiole is to split the petiole along the longitudinal axis into 3 or 4 splits, which are tied into bundles and immersed in water. The retting period varies from a few weeks to 2–3 months. After retting, the fibres can be stripped off relatively easily. Retting influences the appearance of the fibres. Sherbro and Sulima piassava, somewhat pale coloured at harvest, turn brownish on retting. Material retted in fresh running water tends to be pale brown, whereas material retted in stagnant swamp pools develops a reddish-brown tinge, which is attractive and leads to higher prices. The extracted fibres still have a coating of decomposing background tissue which has to be removed. In the case of Sherbro and Sulima, the retted strips are usually flogged over and drawn through a comb of pointed sticks. Fibres may also be separated and cleaned by hand. The cleanliness of the fibre has a large impact on quality and market value. Cleaned fibres may be spread out to dry in the sun for a few days. Further drying may occur under the eaves of houses or above fireplaces. Fibres which are not properly dried become mouldy and brittle and can be a fire hazard in warehouses and ships. Fibre length is an important attribute as long fibres provide more opportunities for further processing. It is also important that bundles consist of fibres of uniform length. High quality Sherbro and Sulima fibres show little variation in length and are about 1.5 m long. Although shorter fibres are acceptable, they should not be shorter than 25–30 cm. Sherbro and Sulima fibres are normally packed in bundles of 25 kg. Traditionally, bundles of fibres of differing lengths are transported to local markets, where they are weighed and priced. The buyer then mixes fibres from different sources before trimming and tying them into uniform bundles of 70–100 cm diameter.

Genetic resources and breeding *Raphia palma-pinus* is widespread in the western part of West Africa, but it is widely exploited and its habitat is threatened by many factors, including loss of wetlands for crop farming, and drought. The level of harvesting is increasing and the palm population is believed to be decreasing. However, according to the IUCN Red list more information is needed on the population decline and impacts of threats before the conservation status of the species can be fully assessed.

Prospects *Raphia palma-pinus* will remain a useful local source of thatch, rope, brushes and material for furniture and construction. The importance in international trade of African piassava fibre has declined sharply following the advent of plastic substitutes, but there is still demand for natural brush-fibres. This demand may even increase in the future as environmentally friendly, traditional products gain popularity.

Major references Burkill, 1997; Ouedraogo, 2008; Russell, 1965; Tuley, 1994; Vanden Berghen, 1988.

Other references Darbyshire, 2004; Goteni & Silou, 2011; Koni Muluwa & Bostoen, 2008a; Latham, 2004; Letouzey, 1978; Lubini, 1994; Neuwinger, 1998; Purseglove, 1972; Russell, 1968; Van der Veen & Bodinga bwa Bodinga, undated.

Authors M. Brink

RAPHIA SUDANICA A.Chev.

Protologue Bull. Soc. Bot. France 55, Mém. 8: 83 (1908).

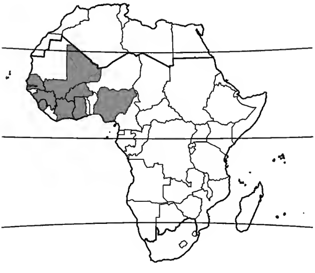
Family Arecaceae (Palmae)

Chromosome number $2n = 28$

Synonyms *Raphia humilis* A.Chev. (1932).

Vernacular names Northern raphia, king bamboo palm, raffia (En). Palmier raphia, raphia (Fr).

Origin and geographic distribution *Raphia sudanica* is distributed from Senegal and Gambia eastwards to northern Nigeria. Plantations have been established in Nigeria.



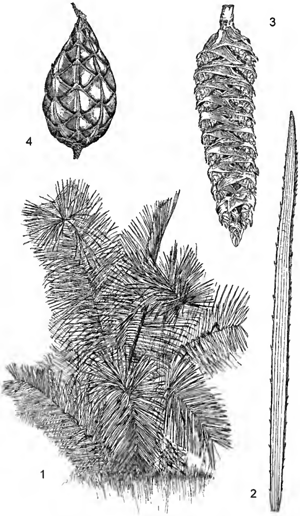
Raphia sudanica – wild and planted

Uses The leaves are used for thatching. The petiole and rachis are used for house construction, furniture, ladders, paddles and canoe poles, and as fuel. They are split for making mats, baskets and arrow shafts. The leaflets are woven into mats, bags, baskets and fish traps. The upper epidermis of the leaflets (raffia fibre) is used for twine and wickerwork.
The stem is used for structural woodwork. The apical bud is tapped for sap to be fermented into palm wine. The fruit and seed are eaten, and the yellow oil expressed from the pulp is used in cooking and as a hair-dressing. The fruit pulp is used as a fish poison. Plant ash is used to blacken masks.
In Senegal a bark infusion is used for washing circumcision wounds, and a bark decoction as an abortifacient. The fruit oil is considered emetic and it is used internally and externally for the treatment of leprosy.

Production and international trade *Raphia sudanica* is an important source of palm wine in Guinea and Nigeria.

Properties The major fatty acids in the mesocarp oil and the seed lipids of *Raphia sudanica* are palmitic acid, oleic acid and linoleic acid. The mesocarp oil resembles that from oil palm in colour, taste, odour and chemical composition, except that it contains more linoleic acid, giving it a higher unsaturated acid content.

Botany Monoecious tree, often clustering; trunk 2–3(–10) m tall, stout, with irregular rings and covered with persistent leaf bases. Leaves pinnate, erect, up to 12 m long, sheathing at the base, glaucous-green; petiole relatively short, unarmed; rachis stout, unarmed, orange-yellow, later grey; leaflets linear-lanceolate, 50–75 cm long, stiff, single-fold, acuminate at the apex, lower surface waxy, margins and back of the midvein armed with straight, black spines c. 5 mm long. Inflorescence axillary, up to 2.5 m long, dense, branched to 2 orders; first order branches c. 20 cm long, with large, papery bracts holding flowering branchlets 3–4 cm long. Flowers unisexual; male flowers with calyx tubular and 3-lobed, petals long and narrow, sharply pointed, not thickened near the tip, stamens 10–12(–18), inserted on the corolla, filaments fused for half their length; female flowers with thin outer bracteole enclosing the calyx and corolla, and inner bracteole about half as long as calyx, calyx 3-lobed, slightly fimbriate, corolla cup-



Raphia sudanica – 1, habit; 2, leaflet; 3, part of the inflorescence; 4, fruit.
Source: Flore analytique du Bénin

shaped for half its length, with 3 lobes, staminodes 9(–18), in a short ring, ovary superior. Fruit obovoid, 5–8 cm × c. 4.5 cm, with a blunt beak 4–8 mm long, covered with scales in (8–) 9–10(–11) longitudinal rows; scales reddish or yellowish, with brown margins; mesocarp yellow. Seed ovoid, testa wrinkled and warty.

Raphia species have monocarpic stems, i.e. they flower and fruit only once, followed by death.

Raphia comprises c. 20 species, mostly African, predominantly found in swampy areas. One species, *Raphia taedigera* (Mart.) Mart., is found in tropical America. *Raphia sudanica* is sometimes included in *Raphia mambillensis* Otedoh, a stemless or almost stemless palm with large leaves rising up to 7 m high, distributed in Nigeria, Cameroon, the Central African Republic and Sudan; it is sometimes cultivated. The leaves of *Raphia mambillensis* are used for thatching, and the petiole and rachis are used as poles in house construction. The palm is tapped for palm wine, the seed is chewed like kola nuts, and the fruit is used as a fish poison. *Raphia africana* Otedoh is a usually 2–4-stemmed palm up to 10 m tall, distributed in Nigeria and Cameroon; it is sometimes cultivated. It yields piassava fibre, raphia fibre and palm wine. The midribs of the leaves are used for house construction, beds, benches and stools. Edible larvae are collected from dead trunks.

Ecology *Raphia sudanica* occurs in freshwater swamps and riverine forest in the savanna zone. It tolerates drier conditions than other *Raphia* spp. It is always gregarious and locally abundant, forming dense thickets.

Management *Raphia* palms are generally propagated by seed, but *Raphia sudanica* can also be propagated by suckers. Fruit rot, caused by *Thielaviopsis paradoxa* (synonym: *Chalara paradoxa*) affects *Raphia sudanica* in Nigeria, causing dark brown rot of the mesocarp. It is a weak pathogen entering fruit via wounds, sometimes killing the embryo, and leading to loss of planting material. In Senegal raffia fibre is obtained by retting of the leaflets.

Genetic resources and breeding In view of its wide distribution and local abundance *Raphia sudanica* seems not threatened with genetic erosion, although it is locally under pressure.

Prospects Like various other *Raphia* species, *Raphia sudanica* is a very useful local source of a range of products, including construction material, palm wine, oil and traditional medicines. As it occurs in drier climatic zones than other *Raphia* species, it has a unique position within the genus, and it is unlikely to lose importance.

Major references Akoègninou, van der Burg & van der Maesen, 2006; Arbonnier, 2004; Burkill, 1997; Russell, 1965; Vanden Berghen, 1988.

Other references Geerling, 1985; IPK, undated; Ndon, 1985; Neuwinger, 2000; Opute, 1978; Oruade-Dimaro, 1987; Otedoh, 1974; Purseglove, 1972; Russell, 1968; Uhl & Dransfield, 1987.

Sources of illustration Akoègninou, van der Burg & van der Maesen, 2006.

Authors M. Brink

RAPHIA VINIFERA P.Beauv.

Protologue Fl.Oware 1: 77 (1806).

Family Arecaceae (Palmae)

Chromosome number $2n = 28$

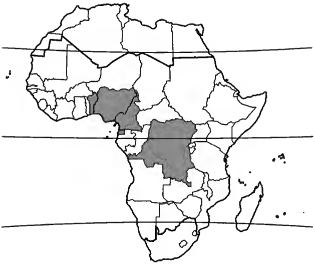
Synonyms *Raphia diasticha* Burret (1942).

Vernacular names Bamboo palm, king bamboo palm, raphia palm (En). Palmier bambou, palmier raphia, raphia (Fr).

Origin and geographic distribution *Raphia vinifera* is distributed from Benin eastwards to DR Congo. Records of its occurrence more to the west are due to misidentification. *Raphia vinifera* is grown in Nigeria and Cameroon.

Uses The epidermis of young leaflets yields raffia fibre which is locally used for making baskets, mats, hats, bags, ropes, hammocks and ceremonial costumes. It may be woven into cloth. The Kuba people in DR Congo are well known for weaving beautiful raffia cloth used, for instance, as ceremonial dance skirts and embroidered cloth panels for court rituals. In Europe raffia fibre (mainly from *Raphia farinifera* (Gaertn.) Hyl.) is used as tying material for horticulture and handicrafts. The leaves are highly valued for thatching. The petiole and rachis of the leaves of *Raphia vinifera* are often used as poles and rafters and for making furniture items such as stools, bedsteads and benches. Split midribs are woven into floor-mats. In Benin and Nigeria the stems are commonly used for house frames.

The tree is sometimes used for tapping sap to be fermented palm wine, but not very often, because the taste of the wine is not appreciated. The oily mesocarp is eaten and can be fermented into a strong drink. The raw fruit is used as a bait for birds and as a fish poison. A decoction of the apical bud is taken for the treatment of gonorrhoea and other genito-urinary infections.



Raphia vinifera – wild and planted

Production and international trade Most of the raffia of international commerce is produced in Madagascar from *Raphia farinifera*.

Properties Raffia fibre is well suited to horticultural purposes, because it is supple and durable and it does not have sharp edges which might damage tender plant parts. It is easily dyed, making it suitable for the production of fancy articles. The quality of raffia fibre from *Raphia vinifera* is less than that of *Raphia hookeri* G.Mann & H.Wendl., because in the latter the hypodermic layer of the leaflets consists of thick fibres arranged in a continuous ribbon-like layer, whereas in *Raphia vinifera* the fibres are not arranged in a ribbon-like layer, but discontinuously, which accounts for the lesser tenacity of their raffia fibre. Thatch from the leaves is said to be durable.

The mesocarp of fruits collected in Nigeria contained 3.6% moisture, 4.4% crude protein, 29.1% fat, 53.4% carbohydrates, 5.6% crude fibre and 4.1% ash. The oil yield of the mesocarp was 28.5%, while the seed yielded only 0.9%. The major fatty acids in the mesocarp oil and the seed lipids of *Raphia vinifera* are palmitic acid, oleic acid and linoleic acid. The mesocarp oil resembles that of oil palm in colour, taste, odour and chemical composition, except that it contains more linoleic acid, giving it a higher unsaturated acid content.

Ethanolic and aqueous extracts of the fruit have shown toxicity to fish in experiments with the African catfish (*Clarias gariepinus*).

Botany Monoecious tree with a stout trunk up to 5 m tall. Leaves pinnately compound, arching, up to 13 m long, sheathing at the base; sheath unarmed, splitting opposite the petiole; petiole channeled above, unarmed; rachis stout, unarmed, pale brown to orange; leaflets linear, up to 150 cm long, single-fold, bright green and shiny above, fairly glaucous and waxy below, margins and main veins spiny. Inflorescence axillary, pendulous, up to 150 cm long, branched to 2 orders; bracts of peduncle and branch-bases ring-like; partial inflorescences 30–60 cm long; rachillae in 4 ranks, lax, slender, 10–15 cm long, curved, laterally compressed, tapering, with flowers in 2 rows. Flowers unisexual; male flowers at apex of inflorescence branchlets, female flowers at base; male flowers curved, 8 mm long, bracteole sharply 2-keeled and enclosing the calyx, calyx almost cup-shaped, 3-lobed, corolla c. 3

times as long as calyx, splitting into 3 segments, slightly thickened at the apex, stamens (6–)9, inserted on the corolla, filaments thick, free or connate for half their length; female flowers with outer bracteole slightly longer than calyx, calyx cup-shaped, 3-toothed, corolla one third longer than calyx, divided halfway into 3 pointed segments, staminiodal ring fused to corolla, with 9 sterile anthers, ovary superior, 3-celled. Fruit cylindrical-ellipsoid, 5–9 cm × 3–4 cm, with a sharp beak 3–5 mm long, covered with scales in (8–)9 rows, usually 1-seeded; scales rhomboid, c. 20 mm × 20 mm, flat or concave towards the point, yellow-brown. Seed ovoid to ellipsoid; mesocarp oily; endosperm deeply ruminate.

Raphia comprises c. 20 species, mostly African, predominantly found in swampy areas. One species (*Raphia taedigera* (Mart.) Mart.) is found in tropical America. *Raphia taedigera* is very similar to *Raphia vinifera* and the hypothesis has been put forward that it was derived from plant material of the latter that arrived from Africa by ocean currents. *Raphia australis* Oberm. & Strey ('kosi palm'), a single-stemmed palm up to 24 m tall, occurring only in southern Mozambique and north-eastern South Africa, was long considered conspecific with *Raphia vinifera*. It has erect inflorescences, however, whereas those of *Raphia vinifera* are pendulous. The large leaves are sometimes used for thatching. The buoyant petioles are used for rafts and as outriggers for canoes. They are also used for house construction and fences.

Raphia species have monocarpic stems, i.e. they flower and fruit only once, followed by death. Inflorescences are produced more or less simultaneously in the axils of the most distal leaves. Tapping for wine may damage the developing inflorescence, making flowering impossible and accelerating death. The time from planting to flowering in *Raphia vinifera* is about 8 years.

Ecology *Raphia vinifera* is found in swamps and other moist locations, especially on the edges of creeks.

Management *Raphia* palms are generally propagated by seed. In nurseries, a spacing of 30 cm × 30 cm is recommended. Seedlings may be collected from the wild and raised in a nursery before being planted out in the field. *Raphia vinifera* is also propagated by suckers. Propagation by tissue culture techniques may offer potential for *Raphia*.

Fruit rot, caused by *Thielaviopsis paradoxa* (synonym: *Chalara paradoxa*) affects *Raphia vinifera* in Nigeria, causing dark brown rot of the mesocarp. It is a weak pathogen entering fruit via wounds, sometimes killing the embryo, and leading to loss of planting material. The aphid *Cerataphis palmae* may cause considerable damage to *Raphia vinifera*, e.g. in Nigeria.

Genetic resources and breeding No germplasm collections or breeding programmes of *Raphia vinifera* are known.

Prospects Like various other *Raphia* species, *Raphia vinifera* is a very useful local source of a range of products, including raffia fibre, construction material, palm heart, oil and traditional medicines. Oil from the mesocarp has been proposed as a biodiesel, but this this does not seem a viable option because *Raphia vinifera* only flowers and fruits once before dying.

Major references Burkill, 1997; de Souza, 1982; Russell, 1965; Russell, 1968; Rustiami & Brink, 2003.

Other references Akoègninou, van der Burg & van der Maesen, 2006; Enobakhare, 1994; Fafioye, Adebisi & Fagade, 2004; Glen, 2004; Igwenyi et al., 2008; Oruade-Dimaro, 1987; Otedoh, 1974; Urquhart, 1997; van Wyk & Gericke, 2000; van Wyk & van Wyk, 1997.

Authors R.B. Jiofack Tafokou

RAVENEA LAKATRA (Jum.) Beentje

Protologue Kew Bull. 49(4): 662 (1994).

Family Arecaceae (Palmae)

Synonyms *Louvelia lakatra* Jum. (1927).

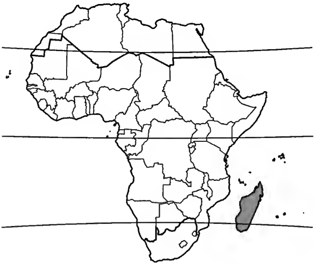
Vernacular names Ironwood palm (En). Palmier majestueux (Fr).

Origin and geographic distribution *Ravenea lakatra* is endemic to Madagascar, where it occurs in the eastern part of the country between Andasibe and Vangaindrano.

Uses The young leaves are used for weaving high-quality hats. The palm heart is eaten, and the stems are used as irrigation pipes.

Properties The weaving material from *Ravenea lakatra* is popular because of its light colour. All woody parts of the palm are very hard.

Botany Dioecious, medium-sized palm with solitary trunk 4.5–14 m tall and 13–17 cm in diameter at breast height, with a layer of black fibres in the outer part of the stem, the nodes over the whole length of the trunk set with up to 7 cm long woody leaf sheath base remnants; crown shaft absent. Leaves 8–10 in crown, spi-



Ravenea lakatra – wild

rally inserted, pinnately compound, slightly arching; sheath 75–80 cm long, with downward-pointing fibres on the margins, densely white-hairy, with black internal fibres; petiole 80–160 cm long, channelled with very sharp edges, with white or grey hairs but glabrescent; rachis 2.5–3.5 m long, with white or grey hairs but glabrescent; leaflets 87–98 on each side of the rachis, in one plane, stiff, medium green, with sinuous transverse veins connecting the longitudinal veins, basal leaflets up to 102 cm long, median leaflets up to 77 cm long, upper leaflets up to 49 cm long. Inflorescence unisexual, solitary, between the leaves, branching to 1 order; male inflorescence with rachis c. 92 cm long, branches up to 30 cm long; female inflorescence erect, peduncle 82–130 cm long, bracts up to 140 cm long, rachis 44–86 cm long, with 50–70 branches up to 65 cm long, white hairy. Flowers unisexual, 3-merous; male flowers with sepals connate for 1 mm, stamens 6, in 2 series, pistillode short, with rudimentary locules and ovules; female flowers with calyx connate for 2–2.5 mm, staminodes 6, with sterile anthers, gynoecium with 3 unilocular carpels, stigmas 3. Fruit a slightly depressed globose drupe 15–20 mm × 18–21 mm, blackish, with terminal stigmatic remains, 1–3-seeded. Seed 9–10 mm × 5–10 mm, black, with distal acumen 1.5 mm long.

In the Manombo region (south-eastern Madagascar) *Ravenea lakatra* flowers in July–September, and fruits in October–February.

Ravenea comprises 18 species, of which 15 are endemic to Madagascar and 2 endemic to the Comoros. *Ravenea lakatra* is easily recognized by the woody 'steps' (remains of the leaf sheaths) on the trunk, and within the genus it is the only species with acuminate seeds. The leaves of *Ravenea xerophila* Jum. (anivona palm), a dioecious palm with a solitary trunk up to 8 m tall, occurring in dry forest in southern Madagascar, are used to weave hats and winnowing baskets. The species is one of the most drought tolerant palms of Madagascar. It is classified as endangered in the IUCN Red list of threatened species, as it occurs in low numbers in only 2 locations, one of which is being destroyed by overgrazing. Outside Madagascar *Ravenea xerophila* is grown as an ornamental.

Ecology *Ravenea lakatra* occurs at 100–850 m altitude in moist lowland forest on slopes or ridge crests.

Management The harvesting of young leaves for weaving prevents the palms from growing, and in practice most populations are pruned to a perpetually juvenile rosette stage.

Genetic resources and breeding *Ravenea lakatra* is classified as endangered in the IUCN Red list, as it occurs in low numbers in few locations, several of which are being destroyed rapidly. The population at Mantady consists of pruned rosettes only.

Prospects As *Ravenea lakatra* is an endangered species, in-situ and ex-situ conservation activities are of the highest importance. In its current area of distribution exploitation of this species should be made sustainable. Introduction into other locations such as botanical gardens and reforestation sites should be encouraged, and supported by research on appropriate propagation and management practices.

Major references Beentje, 1994a; Byg & Balslev, 2001a; Dransfield & Beentje, 1995; Rakotomalala, 2005.

Other references Beentje, 1994c; Byg & Balslev, 2003; Dransfield, 1999; Dransfield & Beentje, 1998b; Dransfield & Beentje, 1998c; Jumelle, 1945.

Authors M. Brink

RHYTACHNE ROTTBOELLIOIDES Desv.

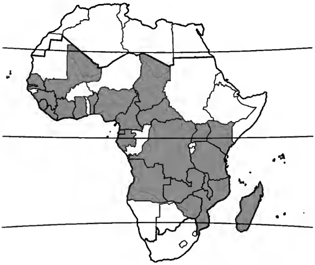
Protologue Ham., Prodr. Pl. Ind. Occ.: 12 (1825).

Family Poaceae (Gramineae)

Chromosome number $n = 16$

Synonyms *Rhytachne mannii* Stapf (1894), *Rhytachne benguellensis* Rendle (1899).

Origin and geographic distribution *Rhytachne rottboellioides* occurs widely in most



Rhytachne rottboellioides – wild

countries of tropical Africa, including Madagascar, and in eastern Latin America, from Cuba to Argentina.

Uses In northern Sierra Leone and in Guinea people make fancy baskets from the stems. Konkomba people in Togo use the stems for making fine, light straw hats. Young growth is grazed by cattle, but is of moderate quality only.

Production and international trade *Rhytachne rottboellioides* is only used and traded locally.

Botany Perennial, densely tufted, slender to robust grass; stems up to 100 cm tall. Leaves alternate; lower parts of lower sheaths persistent; ligule a short membrane; blade narrow, 5–25 cm × 0.5–1 mm, bristly hairy, margins rolled inward. Inflorescence a single, terminal, cylindrical raceme 2–20(–25) cm long; rachis fragile at the nodes; internodes club-shaped, as long as the sessile spikelets, glabrous. Spikelets in pairs, 1 sessile and 1 pedicelled; sessile spikelet fertile, 2-flowererd, narrowly ovate to oblong, 2–5(–6) mm long, convex on the back, callus truncate, with prominent central peg, lower glume oblong, sharply inflexed in the lower half, crustaceous, variously rough with wrinkles or short points, rarely almost smooth, 5–9-veined, apex obtuse, acuminate or with 2 small points, with or without an up to 5 mm long awn, upper glume awnless or with awn up to 5 mm long, basal floret male, lemma lanceolate, nearly as long as spikelet, hyaline, 3-veined, acute, palea present, upper floret bisexual, lemma oblong, hyaline, without keel, 1–3-veined, apex acute, margin ciliolate, palea absent or minute, lodicules 2, stamens 3, ovary 1-locular, stigmas 2; pedicelled spikelet sterile, suppressed or almost so, represented by a curved pedicel as long as the sessile spikelet, sometimes with awn up to 5 mm long. Fruit an oblong caryopsis (grain), dorsally compressed.

Rhytachne rottboellioides shows extreme variation in habit, size, spikelet size and corrugation of the lower glume, and in the presence or absence of awns. In Benin it flowers in May–October.

Rhytachne is classified in the *Andropogoneae*. It comprises about 12 species and is distributed in the tropics of the Americas and Africa (including Madagascar), with 1 species in China. The genus is badly in need of revision.

Rhytachne subgibbosa (Winkl. ex Hack.) Clayton is widespread in South America. Remarkably, it also occurs by Lake Bangweulu in northern Zambia. While the Zambian specimens are extreme in almost all features for *Rhytachne subgibbosa*, it is too similar to separate it as a distinct species. It has been hypothesized that *Rhytachne subgibbosa* is not distinct from *Rhytachne rottboellioides*, but an incidental cluster of character states in the large gene pool that constitutes the very variable *Rhytachne rottboellioides* on both continents. The annual forms of *Rhytachne rottboellioides* in Latin America have been classified in a separate species: *Rhytachne gonzalezii* Davidse.

Ecology *Rhytachne rottboellioides* grows in swamps and seasonally wet grassland, sometimes on shallow soils over iron-pans, from sea-level up to 2250 m altitude near the equator and up to 1500 m altitude near the tropic of cancer. It is able to quickly invade humid fallow land. In Malawi *Rhytachne rottboellioides* is a weed of irrigated rice fields.

Management *Rhytachne rottboellioides* only grows wild.

Genetic resources and breeding As *Rhytachne rottboellioides* is extremely widely distributed and sometimes weedy, its great genetic variability does not seem to be in danger of genetic erosion.

Prospects *Rhytachne rottboellioides* is likely to remain a fodder grass of moderate quality and of local interest only as a source of material for wickerwork.

Major references Burkill, 1994; Clayton & Renvoize, 1982; Clayton et al., 2002–; Cope, 2002; Robyns, 1929.

Other references Akoègninou, van der Burg & van der Maesen, 2006; Clayton, 1966a; Clayton, 1970b; Clayton, 1973; Clayton, 1978; Davidse, 1984; Dujardin, 1978; Poilecot, 1995; van der Zon, 1992.

Authors L.P.A. Oyen

SALACIA MANNII Oliv.

Protologue Fl. trop. Afr. 1: 376 (1868).

Family Celastraceae (Hippocrateaceae)

Synonyms *Salacia soyauxii* Loes. (1894).

Origin and geographic distribution *Salacia mannii* is distributed from Nigeria eastwards through Cameroon, Equatorial Guinea and Gabon to DR Congo. It has not been recorded in Congo.

Uses The stems of *Salacia mannii* are extremely strong and in DR Congo they are made into snares to trap elephants. Many *Salacia* species produce edible fruits but for this specific species this has not been confirmed.

Botany Shrubby bush, sometimes scandent, up to 6 m tall or woody liana up to 15 m tall; bark warty, lenticellate; twigs green becoming reddish brown. Leaves opposite or subopposite, simple; stipules absent; petiole 3–10 mm long; blade elliptical, 8–23 cm × 2.5–9 cm, rounded to obtuse at base, acuminate at tip, margin entire or slightly dentate, deep green and glossy above, paler beneath, with 5–8 pairs of secondary veins. Inflorescence an axillary glomerule with up to 10 flowers. Flowers bisexual, yellow to whitish, 5–10 mm in diameter; pedicel 5–24 mm long; calyx 5-lobed, lobes unequal, up to 2.5 mm wide; petals 5, cream, free, 2–5 mm × 1.5–2 mm; stamens 3, yellow, 0.5–1.5 mm long; ovary 3-celled, yellow, style weakly 3-lobed, very short. Fruit ovoid to elliptical, 4–7 cm × 2.5–3.5 cm, with base and tip attenuate, orange-red when ripe, 2–6-seeded. Seeds 10–22 mm long.

Salacia comprises 180–200 species distributed throughout the tropics, with c. 30 species in America and c. 90 in Africa. The forests of Cameroon and Gabon house around 60 species and Madagascar only 2.

Ecology *Salacia mannii* occurs in forest and gallery forest from sea-level up to 900 m altitude.

Genetic resources and breeding There are no known germplasm collections of the species and there is no apparent threat for *Salacia mannii.*

Prospects As a plant resource *Salacia mannii* will not play an important role in future unless new utilisations are discovered.

Major references Hallé, 1990; Wilczek, 1960b.

Other references Hallé, 1962; Keay & Blakelock, 1958; Lebrun & Stork, 2010.

Authors C.H. Bosch

SANSEVIERIA AETHIOPICA Thunb.

Protologue Prodr. Pl. Cap. 65 (1794).

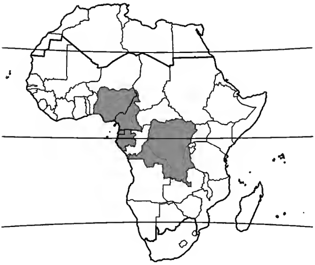
Family Dracaenaceae (APG: Asparagaceae)

Chromosome number $2n = 40$

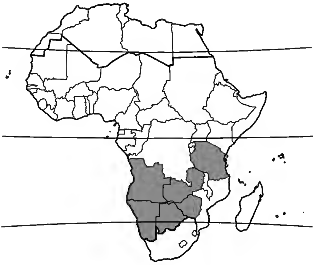
Vernacular names Bowstring hemp, piles root, mother-in-law's tongue (En). Mkonge (Sw).

Origin and geographic distribution *Sansevieria aethiopica* is distributed in Tanzania, Zambia, Angola, Namibia, Botswana, Zimbabwe and South Africa.

Uses The leaf fibres of *Sansevieria aethiopica* are used to make strong twines and ropes. Like several other species of the genus it is



Salacia mannii – wild



Sansevieria aethiopica – wild

especially valued to make bowstrings, hence the vernacular name. The Himba of Namibia use the fibre to make clothing. In Botswana it is used to make fishing lines and nets and the rope is used to make sleeping mats by tying thick papyrus stems together.

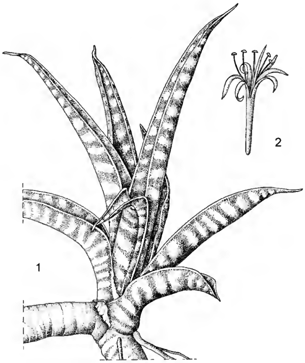
The rhizomes are a source of drinking water obtained by chewing and spitting out the fibres. *Sansevieria aethiopica* is planted as an ornamental in pots and gardens. The medicinal use of rhizomes and leaves is widespread in southern Africa. In Zimbabwe the leaves are heated and the sap is squeezed into the ear to treat ear-infections, while the rhizome is warmed and used for treating toothache. Fresh or boiled rhizomes are eaten to treat haemorrhoids, stomach-ache, ulcers, diarrhoea and internal parasites. In Namibia Bushmen apply the heated, pounded leaves to a stiff neck to give relief. Leaf sap is applied to wounds to accelerate healing and to maternal breasts to stimulate milk production.

Production and international trade *Sansevieria* fibre is mainly used locally in countries where the species occurs. No recent production and trade data for *Sansevieria* are available.

Properties Rhizomes and leaves contain ruscogenin and related sapogenins, which have anti-inflammatory and venotonic properties. Antibacterial tests have given negative results.

Adulterations and substitutes The traditional use of fibre of *Sansevieria* in some parts of southern Africa is diminishing as it is gradually replaced by fibres of the introduced sisal (*Agave sisalana* Perrine). All natural fibres face strong competition from synthetic products, such as polypropylene and nylon.

Description Perennial, rhizomatous herb, without stem, usually forming large groups; rhizome rounded, subterranean, c. 12 mm in diameter, bearing thin, fibrous, orange-grey roots. Leaves 13–30 in a rosette; petiole absent; blade narrowly linear, 13–43 cm × 1–2 cm, erect to slightly spreading, half-folded, mottled with darker, irregular, transverse bands, margin red with colourless outer ridge. Inflorescence a spike-like raceme 35–75 cm long, densely flowered; peduncle with scattered membranous bracts. Flowers bisexual, regular, 3-merous; pedicel c. 5 mm long; perianth tubular, c. 5 cm long, globose around the ovary, lobes 6, c. 13 mm long, white, purple or cream with a tinge of pink or purple; stamens 6, much exserted; ovary superior, 3-celled, style filiform and long, stigma capitate. Fruit a berry, c. 10 mm in diameter, red, 1–3-seeded. Seeds c. 5 mm long, white.



Sansevieria aethiopica – 1, plant habit; 2, flower. Redrawn and adapted by Achmad Satiri Nurhaman

Other botanical information *Sansevieria* has been variously included in the families *Amaryllidaceae*, *Liliaceae*, *Agavaceae* and *Dracaenaceae*, on the basis of morphological characters. Recent taxonomic work based on molecular DNA characters has seen the genus *Sansevieria* treated variously under the families *Convallariaceae*, *Ruscaceae* and, more recently, *Asparagaceae*. Proposals have been put forward to merge the genus *Sansevieria* with its putative sister group *Dracaena*. The genus numbers c. 60 species, but in view of various taxonomic treatments and conflicting delimitations of species, a thorough revision of the genus is needed. Recently, a subspecies of *Sansevieria aethiopica* has been described for Kenya but so far it is only known from the type specimen.

Various other *Sansevieria* species occurring in East and southern Africa are used as ornamentals, for fibre and for traditional medicine. *Sansevieria hyacinthoides* (L.) Druce (synonym: *Sansevieria thyrsiflora* Petagna) and *Sansevieria pearsonii* N.E.Br. (synonym: *Sansevieria desertii* N.E.Br.) are used in the same way as *Sansevieria aethiopica*. *Sansevieria hyacinthoides* is a native of Tanzania, Malawi, Zambia, Zimbabwe, Mozambique and South Africa, and has 2–8 leaves in a rosette. *Sansevieria hyacinthoides* has been produced commercially in Mexico, with exports to the United States. *Sansevieria pearsonii* grows wild in Angola, Namibia, Botswana and Zimbabwe, and has 5–9 opposite cylindrical leaves with a narrow groove on the inside. In literature, the name *Sansevieria guineense* has frequently been used as a synonym for *Sansevieria hyacinthoides*. *Sansevieria cylindrica* Bojer ex Hook. is only recorded in Angola and Zambia but the name *Sansevieria cylindrica* has often been misused outside the range of the species for any *Sansevieria* plant with cylindrical leaves. There are no recorded uses for the species from either Angola or Zambia. The true *Sansevieria zeylanica* (L.) Willd. ('Ceylon bowstring hemp') is native to and cultivated as a fibre plant in Sri Lanka. It has been introduced and is naturalized in Madagascar and Mauritius. It is not confirmed to be present on the African continent. The name *Sansevieria zeylanica* as applied to *Sansevieria* specimens from continental Africa, refers mostly to *Sansevieria aethiopica*.

Anatomy In cross-section, *Sansevieria* leaves are divided into a peripheral region of green chlorenchyma tissue and a central region of water-storage tissue. Fibre bundles are present throughout the leaf but are largest and most prominent in the chlorenchyma.

Growth and development *Sansevieria* species are slow growing and use the Crassulacean Acid Metabolism (CAM) pathway. CAM plants are able to fix CO_2 at night and to photosynthesize with closed stomata during the day, thus minimizing water loss. The delicately scented flowers of *Sansevieria aethiopica* open late in the afternoon and remain open for a single night.

Ecology *Sansevieria aethiopica* occurs in dry open places, savanna and woodland on well-drained sandy or rocky soil. Minimum annual rainfall requirements of *Sansevieria* spp. are c. 250 mm. For commercial production a warm, moist climate and well-drained, somewhat calcareous soils are recommended. Shading is sometimes recommended, but its favourable effect may be due more to its influence on soil moisture and nutrient status than to a direct effect on plants.

Propagation and planting Propagation of *Sansevieria* spp. is easily done by division, suckers, leaf cuttings, seed or in-vitro culture.

Harvesting Leaves are harvested during the growing season as fibres harvested during the dry season are weaker. Best yields and quality of fibres are obtained by respecting a harvest interval that is long enough to not reduce the leaf-length. A first harvest could take place at 2.5–3.5 years after planting and consecutive harvests at 2 year intervals. At a high growth rate the harvest interval can be shorter.

Yield The highest annual *Sansevieria* yield recorded of 3.1 t/ha was realized using the hybrid 'Florida H-13', a cross of *Sansevieria trifasciata* Prain with *Sansevieria pearsonii*.

Handling after harvest The leaf is placed on a soft surface, usually a leg or a thigh, and is scraped with a wooden tool. If this is done on a hard surface the fibres break. Scraping continues till all green material has been removed and the white fibres remain. The fibres are divided in three equal bundles and are rolled on the thigh with the palm of the hand. The result is a very strong twine or rope. This method of preparation is commonly used for most *Sansevieria* species of Africa. Short pieces are joined together to form one long string. It is then hooked around the toe and allowed to coil up on itself, producing a double string, which makes it stronger.

Genetic resources A number of *Sansevieria* species are stored in germplasm collections notably in those of the Millennium Seed Bank Project, United Kingdom, and the National Genebank in Muguga, Kenya. *Sansevieria aethiopica* is not a threatened species since there are no reports of the species being overexploited.

Breeding In the United States the potential of various *Sansevieria* spp. was examined for replacing sisal and abaca (*Musa textilis* Née) as a source of marine fibre. *Sansevieria trifasciata* was considered the most suitable species, because of its leaf length, fibre content and tolerance to cold. In hybrids with *Sansevieria aethiopica* the dwarf habit of the latter proved dominant which reduced the practical value of the hybrids for fibre production.

Prospects The fibres of *Sansevieria aethiopica* will remain important for local usage. In the event of increased worldwide demand for natural fibres in the future, a species with higher fibre yield then *Sansevieria aethiopica* will need to be considered. Opportunities for breeding and selection of high-yielding hybrids are great considering the large gene pool and the high number of species in the genus *Sansevieria*.

Major references Kirby, 1963; Newton,

2001; Obermeyer, 1992; Praptosuwiryo, 2003; Takawira-Nyenya, 2006; van Wyk & Gericke, 2000.

Other references APG III, 2009; Baker, 1915; Dahlgren, Clifford & Yeo, 1985; Decary, 1946; Hanelt & Institute of Plant Genetics and Crop Plant Research (Editors), 2001; Hegnauer, 1986; Imamura-Hayaki, 1996; Leger, 1997; Malan & Owen-Smith, 1974; Menzel & Pate, 1960; Mwachala & Mbugua, 2007; Neuwinger, 1996; SEPASAL, 2011e; van Wyk, van Oudtshoorn & Gericke, 1997; von Koenen, 2001; Watt & Breyer-Brandwijk, 1962; Wijnands, 1973; Wilson, Joyner & Fishler, 1969.

Sources of illustration Obermeyer, 1992.

Authors R. Takawira-Nyenya

SANSEVIERIA EHRENBERGII Schweinf. ex Baker

Protologue J. Linn. Soc., Bot. 14: 549 (1875).

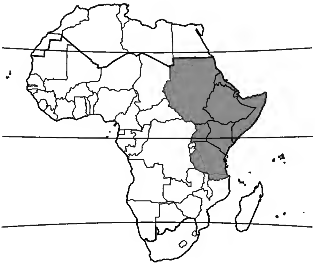
Family Dracaenaceae (APG: Asparagaceae)

Chromosome number $2n = 40$

Vernacular names Seleb sansevieria, blue sansevieria, Somaliland bowstring hemp (En). Mkonge (Sw).

Origin and geographic distribution *Sansevieria ehrenbergii* is distributed in all countries of East Africa and is also native to Yemen and Oman.

Uses In Ethiopia *Sansevieria ehrenbergii* is the most common of the five species of *Sansevieria* that are found in the country, and the leaves are harvested in large quantities for the extraction of the fibres. The fibres are used to make brushes, straps for carrying gourds, in the construction of huts and to tie bundles. The young leaves and fruits are eaten by goats, the rhizomes by cattle. The plants exude an edible gum. The fruits are made into beads. In Kenya it is one of several *Sansevieria* spp. planted for soil conservation, for land reclamation and as a living fence.



Sansevieria ehrenbergii – wild

In traditional medicine in Kenya leaf sap is rubbed into wounds to promote healing and whole leaves are warmed up and placed on aching body parts for pain relief. Leaf sap is applied to aching teeth. In Tanzania leaf sap is used to cure skin infections. The fruits are used in Yemen to treat warts and as an antiseptic.

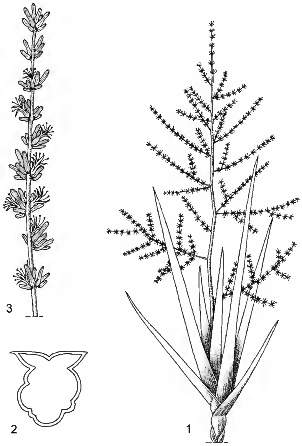
Properties The fibres are tender, smooth and have a long lifespan. Fibre from the interior of the leaf is finer than that from the outer parts.

The aerial parts of *Sansevieria ehrenbergii* were found to contain 3 spirostanol and 3 steroidal saponins. Out of these 6 compounds, 5 caused inhibition of cancer cell growth. In addition, the majority of these saponins exhibit antimicrobial activity, for instance against the pathogenic fungi *Candida albicans* and *Cryptococcus neoformans*. In tests the methanol extract of the fruits proved very active against several opportunistic fungal pathogens and showed cytotoxicity against human epithelial cells with a IC_{50} of 30 μg/ml.

Adulterations and substitutes Like all natural fibres, *Sansevieria* fibres face strong competition from synthetic products, such as polypropylene and nylon.

Description Perennial, rhizomatous herb with or without stem, sometimes forming dense stands; rhizome rounded, subterranean, c. 3 cm in diameter; stem usually up to 25 cm tall. Leaves 5–9(–13), crowded; stipules absent; petiole absent; blade erect or more or less spreading, laterally compressed with flattened sides and rounded back, usually 180–300 cm × 2.5–3.5 cm, tapering upwards, ending in stout spine c. 9 mm long, dark bluish green, margin reddish brown with white edges. Inflorescence a panicle 2–3 m long, much branched in lower part; peduncle with long bracts ; branches 25 cm long or more bearing clusters with 4–7 flowers. Flowers bisexual, regular, 3-merous; pedicel c. 3 mm long; perianth tubular, tube 5–6 mm long, lobes 6, white to purple; stamens 6, much exserted; ovary superior, 3-celled, style filiform, 14 mm long, stigma capitate. Fruit a berry, c. 10 mm in diameter, green turning orange, 1–3-seeded.

Other botanical information *Sansevieria* has been variously included in the *Amaryllida-*



Sansevieria ehrenbergii – 1, plant habit; 2, cross section leaf; 3, branch of inflorescence. Redrawn and adapted by Achmad Satiri Nurhaman

ceae, the *Liliaceae* and the *Agavaceae* but is nowadays usually placed in the *Dracaenaceae*. This genus of the tropics of the Old World numbers c. 60 species most of them native of Africa. In view of widespread confusion about delimitations of species, a thorough revision of the genus is badly needed.

Several other East African species have a documented fibre use. *Sansevieria bagamoyensis* N.E.Br. is a native of Kenya and Tanzania. It has long stems, spirally arranged leaves over 35 cm long. It yields fibre of good quality. In Tanzania the filtered leaf sap is drunk and applied over the body against convulsive fever. *Sansevieria fischeri* (Baker) Marais (synonym: *Sansevieria singularis* N.E.Br.) is distributed from Ethiopia, and Somalia to Tanzania. Only a single cylindrical leaf is present at any given time. It yields fibre and is much sought after by elephants. *Sansevieria forskaoliana* (Schult.f.) Hepper & J.R.I.Wood (synonym: *Sansevieria abyssinica* N.E.Br.) is distributed in DR Congo and throughout East Africa with the exception of Uganda. It occurs in a wide range of habitats. Records and uses from Côte d'Ivoire are obviously based on misidentifications. It has been introduced in Mauritius where it has become naturalised. In Ethiopia it is used like *Sansevieria ehrenbergii* and is harvested in large quantities. The rhizomes are dug up and sucked to quench thirst. *Sansevieria powellii* N.E.Br. is distributed in Sudan, Somalia, Kenya and Tanzania, while reports from Ethiopia are unconfirmed. It resembles *Sansevieria ehrenbergii* but has taller stems and smaller inflorescences. Its fibres are used in the same way. *Sansevieria raffillii* N.E.Br. is distributed in Sudan, Kenya, Uganda, Tanzania and Botswana. It has 1 or 2 leaves and a tall inflorescence of up to 130 cm. In Kenya its fibres are used to make ropes, mats and clothing. Medicinal uses are similar to those of *Sansevieria ehrenbergii*.

Sansevieria robusta N.E.Br. is a shrubby species with a distribution restricted to DR Congo, Kenya and Tanzania. The Rendille people of Kenya process its fibres into ropes and mats. *Sansevieria suffruticosa* N.E.Br. is considered to be an endemic of Kenya. Records for the species from Honduras and the United States are almost certainly referring to imported, cultivated plants or misidentifications. It is a semi-erect, branching herb with leaves of up to 60 cm long. In the highlands of Kenya fibre and medicinal uses are comparable to those of *Sansevieria ehrenbergii*. The Loita Maasai use the leaf sap to treat gonorrhoea.

Anatomy In cross-section, *Sansevieria* leaves are divided into a peripheral region of green chlorenchyma tissue and a central region of water-storage tissue. Fibre bundles are present throughout the leaf but are largest and most prominent in the chlorenchyma.

Growth and development *Sansevieria* species are slow growing and use the Crassulacean Acid Metabolism (CAM) pathway. CAM plants are able to fix CO_2 at night and to photosynthesize with closed stomata during the day, thus minimizing water loss.

Ecology *Sansevieria ehrenbergii* occurs from sea-level up to 1900 m altitude in open bushland, dry grassland and dunes, often on rocky ground, usually in the shade of small trees or thickets. Minimum annual rainfall requirements of *Sansevieria* spp. are c. 250 mm. For commercial production a warm, moist climate and well-drained, somewhat calcareous soils are recommended. Shading is sometimes recommended, but its favourable effect may be due more to its influence on soil moisture and nutrient status than to a direct effect on plants.

Propagation and planting Propagation of *Sansevieria* spp. is easily done by division, suckers, leaf cuttings, seed or in-vitro culture.

Management Early in the 20th Century a failed attempt has been made to produce *Sansevieria ehrenbergii* fibres on a commercial scale in Voi, Kenya. No details on management have been published.

Harvesting Best yields and quality of fibres are obtained by respecting a harvest interval that is long enough not to reduce the leaf-length. A first harvest could take place at 2.5–3.5 years after planting and consecutive harvests at 2 year intervals. At a high growth rate the harvest interval can be shorter.

Handling after harvest In Ethiopia the leaves of *Sansevieria ehrenbergii* are retted in water before the fibres are extracted.

Genetic resources A number of *Sansevieria* species is stored in germplasm collections notably in those of the Millennium Seed Bank Project, United Kingdom, and the National Genebank in Muguga, Kenya. The conservation status of East African species that are used for their fibres are classified by CITES as 'Least concern'.

Breeding In the United States the potential of various *Sansevieria* spp. was examined for replacing sisal (*Agave sisalana* Perrine) and abaca (*Musa textilis* Née) as a source of marine fibre. *Sansevieria trifasciata* Prain was considered the most suitable species, because of its leaf length, fibre content and tolerance to cold. Hybrids with *Sansevieria ehrenbergii* have been produced to combine its vigour with the advantages of the former.

Prospects The fibres of *Sansevieria ehrenbergii* will remain important for local usage but even if demand for natural fibres increases, it is probable that other more productive species will be used to fill in the gaps. Opportunities for breeding and selection of high-yielding hybrids are large as a large gene pool is present in the genus.

Major references Bos & Teketay, 1997; Khalumba, Mbugua & Kung'u, 2005; le Floc'h et al., 1985; Mwachala & Mbugua, 2007; Newton, 2001; Praptosuwiryo, 2003; Thulin, 1995b.

Other references Agnew, 1974; Al Fatimi et al., 2007; Baker, 1915; Chhabra, Mahunnah & Mshiu, 1987; Gemedo-Dalle, Maass & Isselstein, 2005; Hanelt & Institute of Plant Genetics and Crop Plant Research (Editors), 2001; Heine & Heine, 1988b; Kirby, 1963; Maundu et al., 2001; Menzel & Pate, 1960; Neuwinger, 2000; Otieno, Lyaruu & Hosea, 2007; Pettit et al., 2005; Wilson, Joyner & Fishler, 1969.

Sources of illustration Agnew, 1974.

Authors C.H. Bosch

SANSEVIERIA LIBERICA Gérôme & Labroy

Protologue Bull. Mus. natl. Hist. nat., Paris 9: 170, 173 (1903).

Family Dracaenaceae (APG: Asparagaceae)

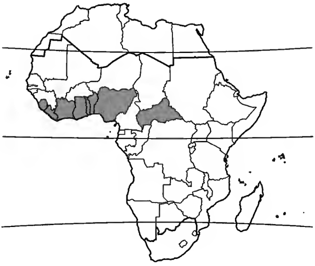
Chromosome number $2n = 80$

Vernacular names Bowstring hemp, leopard lily (En). Sansévière, chanvre d'Afrique, lis léopard, herbe à perruque (Fr).

Origin and geographic distribution *Sansevieria liberica* is distributed from Sierra Leone to Nigeria and in the Central African Republic.

Uses *Sansevieria liberica* has been cultivated in Nigeria for its leaf fibres, that were used for making ropes, bowstrings and fishing-lines. In Ghana the fibres were made into cloth using a handloom. Fibres are still used for threading valuable and sacred ornaments and to make sponges.

In traditional medicine juice pressed from the leaves or a decoction of the leaves is drunk for the treatment of gonorrhoea, earache and toothache. Leaf sap is applied to ulcers, sores and topically in case of earache and toothache. Fermented rhizomes are eaten to cure malaria. A root decoction is used as a remedy for convulsions. In Ghana the roots are used as an abortifacient and administered during labour. As a fetish plant it is grown on graves, at shrines and in compounds.



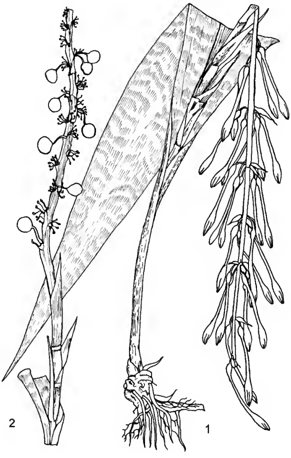
Sansevieria liberica – wild and planted

Sansevieria liberica is widely grown as an ornamental.

Properties In a test with leaf and rhizome extracts no molluscicidal activity was found. The leaves have analgesic properties.

Adulterations and substitutes Like all natural fibres, *Sansevieria* fibres face strong competition from synthetic products, such as polypropylene and nylon.

Description Perennial, rhizomatous herb, without stem; rhizome rounded, subterranean, c. 19 mm in diameter, branched. Leaves 1–6; stipules absent; petiole absent; blade oblanceolate, 45–105 cm × 5–12.5 cm, erect to suberect, spreading with age, dark green usually with paler indistinct, transverse bands, apex narrowed, ending in a flexible, acute tip 2–12 mm long, green turning white, margin cartilaginous, pale reddish brown. Inflorescence a spike-like raceme, 60–80 cm long, laxly flowered; peduncle with persistent membranous bracts, lower bracts c. 4 cm long. Flowers bisexual, regular, 3-merous; pedicel c. 5 mm long; perianth tubular, 5–7 cm long, lobes 6, white; stamens 6, much exserted; ovary superior, 3-celled, style filiform and long, stigma capitate. Fruit a berry c. 10 mm in diameter, red, 1–3-seeded.



Sansevieria liberica – 1, flowering plant habit; 2, infructescence.
Source: Flore analytique du Bénin

Other botanical information *Sansevieria* has been variously included in the *Amaryllidaceae*, the *Liliaceae* and the *Agavaceae* but is nowadays usually placed in the *Dracaenaceae*. The genus numbers c. 60 species but in view of widespread confusion a thorough revision of the genus is badly needed.

Several other West and Central African *Sansevieria* species are used for their fibre. *Sansevieria senegambica* Baker is distributed from Senegal to Côte d'Ivoire. It resembles *Sansevieria liberica* and has been confused with it, but it has smaller leaves and flowers and the leaves are not distinctly banded. It has been cultivated in West Africa for its fibres. The fibre needs special treatment which has restricted its commercial use. Locally the fibre is used for fishing nets, bowstrings and to make hair extensions. Medicinal use of *Sansevieria senegambica* is similar to that of *Sansevieria liberica*. *Sansevieria longiflora* Sims is distributed in Equatorial Guinea, DR Congo, Angola and Namibia. It is claimed to be cultivated for its fibres in Ethiopia, Jamaica, Trinidad and the southern United States, and its English name is 'Florida bowstring hemp'. In Ethiopia the species has not been recorded and for the Caribbean and in the United States a mistaken identity is probable as well.

Growth and development *Sansevieria* species are slow growing and use the Crassulacean Acid Metabolism (CAM) pathway. CAM plants are able to fix CO_2 at night and to photosynthesize with closed stomata during the day, thus minimizing water loss. In West Africa *Sansevieria liberica* flowers from March till June.

Ecology *Sansevieria liberica* is usually found in shaded locations in savanna and forest. Minimum annual rainfall requirements of *Sansevieria* spp. are c. 250 mm. For commercial production a warm, moist climate and well-drained, somewhat calcareous soils are recommended. Shading is sometimes recommended, but its favourable effect may be due more to its influence on soil moisture and nutrient status than to a direct effect on plants.

Propagation and planting Propagation of most *Sansevieria* spp. is easily done by division, suckers, leaf cuttings, seed or in-vitro culture. *Sansevieria liberica* is an exception as using leaf cuttings appears unsuccessful.

Harvesting Best yields and quality of fibres are obtained by respecting a harvest interval that is long enough to not reduce the leaf-length. A first harvest could take place at 2.5–3.5 years after planting and consecutive harvests at 2 year intervals. At a high growth rate the harvest interval can be shorter.

Genetic resources A number of species of *Sansevieria* is stored in germplasm collections notably in those of the Millennium Seed Bank Project, United Kingdom and the National Genebank in Muguga, Kenya. The conservation status of *Sansevieria liberica* is not problematic since its utilisation is limited.

Breeding In the United States the potential of various *Sansevieria* spp. was examined for replacing sisal (*Agave sisalana* Perrine) and abaca (*Musa textilis* Née) as a source of marine fibre. *Sansevieria trifasciata* Prain was considered the most suitable species, because of its leaf length, fibre content and tolerance to cold. Hybrids with *Sansevieria liberica* have been produced to benefit from the higher fibre content of the latter. These hybrids proved to be sterile, could be easily propagated with leaf cuttings but leaves are short which reduced the practical value for fibre production.

Prospects The fibres of *Sansevieria liberica* will remain important for local usage but even if demand for natural fibres increases it is probable that other more productive species will be used to fill in the gaps. Opportunities for breeding and selection of high-yielding hybrids are large as a large gene pool is present in the genus.

Major references Burkill, 1995; Hepper, 1968a; Kirby, 1963; Newton, 2001; Praptosuwiryo, 2003.

Other references Adewunmi & Sofowora, 1980; Akoègninou, van der Burg & van der Maesen, 2006; Baker, 1915; De Wildeman, 1903–1905; Hanelt & Institute of Plant Genetics and Crop Plant Research (Editors), 2001; Hermans, Akoègninou & van der Maesen, 2004; Hodgkin et al., 2007; Ikewuchi, 2010; Menzel & Pate, 1960; Neuwinger, 1996; Wilson, Joyner & Fishler, 1969.

Sources of illustration Akoègninou, van der Burg & van der Maesen, 2006.

Authors C.H. Bosch

SARCOPHRYNIUM BRACHYSTACHYUM (Benth.) K.Schum.

Protologue Engl., Pflanzenr. IV, 48: 36 (1902).

Family Marantaceae

Chromosome number $2n = 28$

Vernacular names Yoruba soft cane (En).

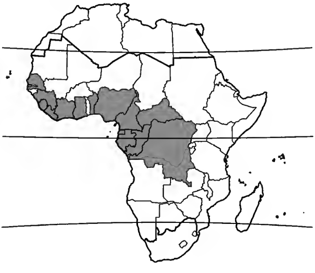
Origin and geographic distribution *Sarcophrynium brachystachyum* is distributed from Senegal to the Central African Republic and DR Congo.

Uses The leaves are widely used for thatching and for wrapping food products, such as cassava. They are used for covering pots in which bananas, yams or taro are cooked, and for baking meat and fish during field camps. In Cameroon they are used as cushion under sleeping mats and made into articles such as instant containers, plates, pots, cups, funnels, fans and parasols. Split petioles, with the central pith scraped out, are used for tying; they are also plaited into mats and baskets. The stems are recorded to be used for making cords, fish traps and baskets.

In Côte d'Ivoire the seeds are credited with expectorant and emetic activity and they are used against pulmonary problems such as cough and bronchitis. For this purpose, they are ground, mixed with water or palm-wine and drunk, or they are taken as small pills. A paste made of pounded seeds and water is applied on abscesses. In Gabon the rhizome is an ingredient of a decoction taken for the treatment of pulmonary problems.

In Nigeria the dried leaves are stored with kola nuts to preserve the nuts.

Production and international trade Infor-



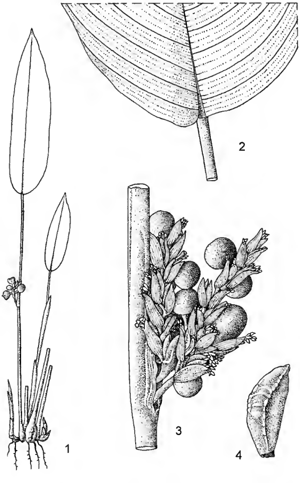
Sarcophrynium brachystachyum – wild

mation on local trade is not available.

Properties The fruit pulp is said to be edible in Ghana, but in Gabon the fruits are recorded not to be edible.

Adulterations and substitutes A range of other *Marantaceae* species are similarly used for thatching, packing, wrapping, tying and weaving.

Description Perennial, erect herb with rhizome and tufts of c. 10 imbricate leaves around a central stem terminated with a single leaf and a lateral inflorescence. Leaves distichous; petiole up to 1.5 m long, sheathing at the base, sheath pubescent, the uncalloused and calloused parts of the petiole not separated by a joint, apical calloused part up to 6 cm long, transition of the petiole into the midvein marked by a V-shaped beak on the upper surface, but continuous on the under surface; blade elliptical to linear-elliptical, 20–40 cm × 10–20 cm, base attenuate. Inflorescence of 1 or more racemes; raceme up to 7 cm long, sessile or with peduncle up to 6 cm, condensed, internodes c. 5 mm long; abaxial bracts overlapping, 10–20 mm × 8–10 mm, persistent, each with 4–5 cymules; cymule 2-flowered, backed by a an adaxial bract. Flowers bisexual, zygomorphic; pedicel c. 1 mm long; bracteole c. 1.5 mm long, acuminate, fleshy, smooth; sepals free, equal; corolla c. 10 mm long, tubular below, with 3 lobes, pinkish white to purplish or yellowish; staminodes and stamen in 2 cycles, at the base forming a tube fused to the corolla tube, outer cycle consisting of 2 petaloid staminodes, inner cycle consisting of 1 stamen and 2 staminodes, of which 1 hooded with a sword-like appendage; ovary inferior, glabrous, 3-locular. Fruit almost globose, 12–15 mm in diameter, with inconspicuous sutures, indehiscent, fleshy, orange-red, wrinkled when dry, 3-seeded. Seeds subpyramidal, oblique, without aril.



Sarcophrynium brachystachyum – 1, plant habit; 2, leaf base; 3, inflorescence; 4, seed.
Redrawn and adapted by Achmad Satiri Nurhaman

Other botanical information *Sarcophrynium* comprises 4–7 species, distributed in the forest regions of tropical Africa.

Within *Sarcophrynium brachystachyum* 2 varieties are distinguished: var. *brachystachyum*, with glabrous leaf blade except for the midvein on the upper surface, and var. *puberulifolium* Koechlin, with fine pubescence on the undersurface of the leaf blade.

Growth and development Flowers open early in the morning and start wilting at around 11.00 in the morning. Pollination is by bees.

Ecology *Sarcophrynium brachystachyum* occurs in forest understorey, particularly in humid locations or along streams. It is also recorded to occur as a weed in oil palm plantations.

Propagation and planting Natural reproduction is rapid.

Genetic resources In view of its wide distribution and rapid natural reproduction *Sarcophrynium brachystachyum* is not threatened with genetic erosion.

Prospects *Sarcophrynium brachystachyum* yields many useful products, but little information is available on the species. Studies on its market value and trade routes, its properties, its germination characteristics, and its phenology seem worthwhile.

Major references Abbiw, 1990; Akoègninou, van der Burg & van der Maesen, 2006; Burkill, 1997; Hattori, 2006; Hawthorne & Jongkind, 2006; Hepper, 1968c; Koechlin, 1965.

Other references Adjanohoun & Aké Assi, 1979; Aiyeloja & Ajewole, 2006; Gassita et al. (Editors), 1982; Kayode, Ige & Ojo, 2009; Ley, 2008; Mangenot & Mangenot, 1958; Missouri

Botanical Garden, undated; Neuwinger, 2000; N'goran et al., 1995; Pischtschan, Ley & Claβen-Bockhoff, 2010; Tchatat, 1999; Zapfack et al., 2001.

Sources of illustration Koechlin, 1964; Schnell, 1953b.

Authors V.A. Kémeuzé & B.A. Nkongmeneck

SARCOPHRYNIUM PRIONOGONIUM (K.Schum.) K.Schum.

Protologue Pflanzenr. IV, 48: 39 (1902).

Family Marantaceae

Chromosome number 2*n* = 28

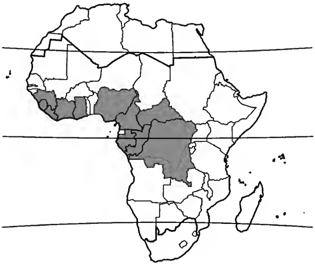
Vernacular names Yoruba soft cane (En).

Origin and geographic distribution *Sarcophrynium prionogonium* is distributed in the forest regions of West and Central Africa, from Guinea to DR Congo and Cabinda (Angola).

Uses The leaves are used for thatching and for wrapping kola nuts and other products. They are also used as mats, for lining carrying baskets, and as disposable plates. In Cameroon they are used as cushion under sleeping mats and made into articles such as instant containers, pots, cups, funnels, fans and parasols. Split petioles, with the central pith scraped out, are plaited into mats.

In Côte d'Ivoire the root pulp is used as a dressing on abscesses, chancres and glandular swellings to soothe pain and to promote cicatrization.

Properties In DR Congo the leaves are said to be apt to tear and become fragile as they dry, and therefore they are not used as often as those of *Ataenidia conferta* (Benth.) Milne-Redh. It is also said that ticks are often present on the leaves. The fruit pulp is mucilaginous and sticky. In the Central African Republic the main components of the essential oil obtained from rhizomes by water-distillation were camphor (31.0%), α-zingiberene (17.8%), β-sesquiphellandrene (13.7%) and isoborneol (8.5%).



Sarcophrynium prionogonium – wild

Botany Perennial, erect herb up to 2 m tall, with rhizome and tufts of c. 10 imbricate leaves around a central stem with a single leaf and a lateral inflorescence. Leaves distichous; petiole sheathing at the base, sheath pubescent, the uncalloused and calloused parts of the petiole not separated by a joint, apical calloused part 4–9 cm long, transition of the petiole into the midvein marked by a V-shaped beak on the upper surface, but continuous on the under surface; blade elliptical, 25–50 cm × 10–20 cm, base rounded, one half cordate, apex acuminate. Inflorescence up to 30 cm long, branched, internodes 15–20 mm long; abaxial bracts not overlapping, 4 cm × 0.5–1 cm, with 3–4 cymules; cymule 2-flowered, backed by a an adaxial bract, common peduncle c. 20 mm long, 1 flower subsessile, the other with a pedicel 2–3 mm long. Flowers bisexual, zygomorphic; bracteole ovate, c. 1.5 mm long, acute, fleshy, smooth; sepals free, equal; corolla c. 6 mm long, tubular below, with 3 lobes, pinkish white; staminodes and stamen in 2 cycles, at the base forming a tube fused to the corolla tube, outer cycle consisting of 2 petaloid staminodes, inner cycle consisting of 1 stamen and 2 staminodes, of which 1 hooded with a sword-like appendage; ovary inferior, glabrous, 3-locular. Fruit 15 mm × 10–12 mm, with unconspicuous sutures, indehiscent, fleshy, red. Seeds subpyramidal, oblique, brown or whitish when dry, without aril.

The flowers are pollinated by bees.

Sarcophrynium comprises 4–7 species, distributed in the forest regions of tropical Africa. *Sarcophrynium schweinfurthianum* (Kuntze) Milne-Redh. is a perennial, erect herb up to 2 m tall distributed in Cameroon, the Central African Republic, Equatorial Guinea, Gabon, Congo, DR Congo, Sudan and Uganda. Its leaves are used for thatching and for wrapping things to be transported or cooked. In Cameroon they are used as cushion under sleeping mats and made into articles such as instant containers, plates, pots, cups, funnels, fans and parasols. In DR Congo the leaves are sometimes used as toilet paper. The petioles are used for plaiting. Young leaves are eaten as a vegetable.

Within *Sarcophrynium prionogonium* 3 varieties are distinguished: var. *prionogonium*, with glabrous leaf blade except for the midvein on the upper surface, var. *puberulifolium* Schnell, with dense and fine pubescence on the undersurface of the leaf blade, and var. *ivorense* Schnell, with hairs with a tubercled base.

Ecology *Sarcophrynium prionogonium* occurs in the understorey of non-swampy forest, disturbed forest and secondary forest.

Management *Sarcophrynium prionogonium* is collected from wild stands.

Genetic resources and breeding In view of its wide distribution and occurrence in disturbed and secondary forest, *Sarcophrynium prionogonium* is unlikely to be threatened with genetic erosion.

Prospects *Sarcophrynium prionogonium* is a useful local source of material for thatching and wrapping, and for the production of a range of products. However, the quality of the leaves is recorded to be lower than that of other *Marantaceae*, and its products are not recorded to be traded in markets. In view of the availability of better-quality *Marantaceae*, such as *Ataenidia conferta*, and synthetic substitutes, *Sarcophrynium prionogonium* is unlikely to become more important.

Major references Abbiw, 1990; Burkill, 1997; Hattori, 2006; Hepper, 1968c; Koechlin, 1965.

Other references d'Oliveira Feijão, 1961; Hawthorne & Jongkind, 2006; Koni Muluwa & Bostoen, 2008b; Lubini, 1994; Menut et al., 1994; Milne-Redhead, 1952; Pischtschan, Ley & Claβen-Bockhoff, 2010; Tanno, 1981; Terashima & Ichikawa, 2003; Thomas, Bahuchet & Epelboin (Editors), 1998.

Authors M. Brink

SCHOENOPLECTIELLA MUCRONATA (L.) J.Jung & H.K.Choi

Protologue J. Pl. Biol. 53(3): 230 (2010).

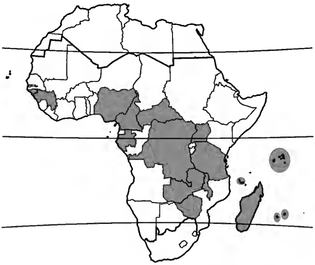
Family Cyperaceae

Chromosome number $2n = 38, 40, 42, 44$

Synonyms *Scirpus mucronatus* L. (1753), *Schoenoplectus mucronatus* (L.) Palla (1888).

Vernacular names Bog bulrush, ricefield bulrush, rough-seed bulrush (En). Scirpe mucroné (Fr). Castanhol (Po).

Origin and geographic distribution *Schoenoplectiella mucronata* is distributed in the tropics, subtropics and warm-temperate regions of the Old World, from southern Europe and Africa through South and South-East Asia to Japan and Australia. It is introduced and naturalized in the southern United States and South America.

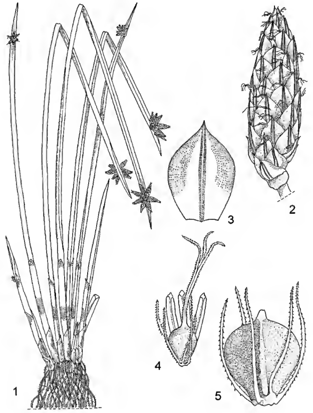


Schoenoplectiella mucronata – wild

Uses The stems are used in Madagascar for making hats. In South-East Asia the stems are used in the production of string, mats, sacks and bags. *Schoenoplectiella mucronata* is sometimes planted as an ornamental in ponds and is considered to have potential as a species in wetlands used for water treatment in the tropics.

Botany Perennial, tufted herb with erect or horizontal rhizome; stems up to 100(–150) cm tall, 2–8 mm wide, sharply triangular in cross-section, indistinctly ridged. Leaves reduced to a sheath; sheath 4–15 cm long, often ending in a triangular apex or minute mucro, pale brown; ligule absent; blade absent. Inflorescence a pseudolateral, dense, head-like cluster of (2–) 4–25 spikelets; main bract stem-like, sharply triangular, 15–30 mm long, acute at the apex, usually erect, occasionally bent back. Spikelets sessile, ovoid to cylindrical, 4–5 mm long at flowering, 30 mm long at fruiting, pale brown, many-flowered; glumes spirally arranged, broadly obovate, concave, 3–4.5 mm long, pale brown; flowers bisexual, perianth consisting of (4–)6 brown bristles with recurved teeth, stamens 3, ovary superior and 1-locular, stigmas 2–3. Fruit an obovoid nutlet, 1.5–2.5 mm × 1–1.5 mm, bluntly 3-angled, blackish, minutely wrinkled.

Schoenoplectiella comprises about 45 species. These were formerly included in *Scirpus* and more recently in *Schoenoplectus*, but recent research including DNA studies has led to a split off.



Schoenoplectiella mucronata – 1, flowering plant; 2, spikelet; 3, dorsal view of opened glume; 4, flower; 5, fruit with bristles.
Source: PROSEA

Schoenoplectiella juncoides (Roxb.) Lye (synonyms: *Schoenoplectus juncoides* (Roxb.) Palla, *Scirpus juncoides* Roxb.; English names: Japanese bulrush, rock bulrush; French name: scirpe faux-jonc) is a perennial, tufted herb with a short rhizome and stems up to 70 cm tall, distributed in Madagascar, the Mascarenes, Asia, Australia and Pacific islands. It is recorded to occur naturalized in Europe. In Madagascar it is used for weaving hats and fine mats. In South-East Asia it is used as a forage and in China it is used medicinally to release heat, to clear the eyes and to relieve coughing. *Schoenoplectiella juncoides* is a very important weed in rice cultivation in Madagascar and elsewhere.

Ecology *Schoenoplectiella mucronata* occurs in pools and swamps. In East Africa it is found at 900–1400 m altitude. It is an important weed in the cultivation of rice and other crops throughout its distribution range.

Management Natural reproduction is by seed, rhizome extension and relocation of plant parts. In Indonesia, where *Schoenoplectiella mucronata* is sometimes cultivated, planting material is obtained by division of old clumps into pieces containing 10–15 stems, which are planted out at a distance of 1 m × 1 m. Before planting, the soil is ploughed or hoed until it is muddy. The stems are harvested 3–4 months after planting, when the flowers have turned brown.

Schoenoplectiella mucronata occurring as a weed in rice cultivation cannot be controlled by flooding, but experiments in the United States have shown that temporary drought can selectively suppress *Schoenoplectiella mucronata* in rice. Successful control of *Schoenoplectiella mucronata* in rice cultivation has been achieved with acetolactate synthase inhibitor herbicides such as bensulfuron-methyl, but resistant forms have been developed in several rice-producing areas.

Genetic resources and breeding In view of its extremely wide distribution and its weedy behaviour, *Schoenoplectiella mucronata* is not threatened with genetic erosion.

Prospects *Schoenoplectiella mucronata* seems not to be used much in tropical Africa. Introduction of this species in new locations is not advisable, because of its weedy behaviour.

Major references Hoenselaar, Verdcourt & Beentje, 2010; Jung & Choi, 2010; Lye, 2003; Simpson & Inglis, 2001; Vanden Berghen, 1988.

Other references Beharrell, 2004; Boiteau, Boiteau & Allorge-Boiteau, 1999; Boulvert, 1977; Bryson & Carter, 2008; Busi et al., 2006; Catarino, Duarte & Diniz, 2001; Fischer et al., 2010; Hooper & Napper, 1972; Jansen & Brink, 2003; Wild, 1962.

Sources of illustration Jansen & Brink, 2003.

Authors M. Brink

SCHOENOPLECTUS SUBULATUS (Vahl) Lye

Protologue Enum. pl. 2: 268 (1805).

Family Cyperaceae

Chromosome number n = 39, 40, 42, $2n$ = 78

Synonyms *Scirpus subulatus* Vahl (1805), *Scirpus litoralis* Schrad. (1806), *Schoenoplectus litoralis* (Schrad.) Palla (1888).

Vernacular names Coast club-rush (En). Scirpe du littoral (Fr).

Origin and geographic distribution *Schoenoplectus subulatus* is distributed in tropical, subtropical and temperate regions from the Mediterranean region and Africa eastward through Asia to Australia and Micronesia. Its distribution in tropical Africa is unclear due to the taxonomic confusion concerning the species.

Uses In Senegal the stems are used for thatching. In Ghana they are used for stuffing mattresses. Outside tropical Africa the stems are used for thatching in Oman and for making mats in Java.

In Oman roasted and peeled stem sections are eaten, or the outer skin is removed and the interior of the stem is eaten raw or boiled. In Egypt the plant is eaten by cattle only when nothing else is available, and in Oman the leaves are fed to cattle when fodder is scarce.

Botany Perennial, loosely tufted herb with a 2–3 mm thick rhizome; stem erect, stout, up to 100(–200) cm × 5(–10) mm, obtusely trigonal in cross-section, glabrous. Leaves often reduced to a sheath or with a short blade; sheath greyish or reddish; blade up to 30 cm × 2–4 mm, but often smaller or absent. Inflorescence a pseudolateral anthela 2–8 cm long, with 3–7 unequal ascending rays, terminated by 1–3 spikelets; largest involucral bract as long as inflorescence; bracteoles scale-like. Spikelets ellipsoid-ovoid, 5–15 mm long, reddish brown, many-flowered; glumes obovate-elliptical, 3–4 mm long; flowers bisexual, perianth consisting of 3–6 spathulate scales, stamens (2–)3, ovary superior and 1-locular, stigmas 2(–3). Fruit a broadly obovoid nutlet, biconvex, 1–2(–3) mm long, shiny brown-black.

Schoenoplectus is distributed in tropical, subtropical and temperate regions. In the past *Schoenoplectus* was a section of the very large and heterogeneous genus *Scirpus*. At present *Scirpus* sensu lato is usually split into smaller, more homogeneous genera and *Schoenoplectus* is one of those, although authors differ in opinion about its delimitation.

Some authors consider *Schoenoplectus subulatus* and *Schoenoplectus litoralis* to be separate species, whereas others consider them to be 1 species. Here, the latter view is followed. The 2 taxa are often combined into *Schoenoplectus litoralis* sensu lato, but this is not correct, as *Scirpus subulatus* was published earlier than *Scirpus litoralis*, and the epithet *subulatus* thus has priority.

A revision in southern Africa has led to the specimens formerly known as *Schoenoplectus litoralis* being classified into *Schoenoplectus subulatus* in Namibia and *Schoenoplectus scirpoideus* (Schrad.) Browning (synonyms: *Scirpus pterolepis* (Nees) Kunth, *Schoenoplectus litoralis* var. *pterolepis* (Nees) C.C.Towns.) in Namibia, Botswana, Mozambique and South Africa. In East Africa specimens from Ethiopia, Somalia, Kenya and Tanzania formerly included in *Schoenoplectus subulatus* are now included in *Schoenoplectus scirpoideus*. A revision of *Schoenoplectus* for other parts of Africa is badly needed.

Ecology *Schoenoplectus subulatus* occurs in brackish swampy locations and in or near saline pools. In Ghana it grows in pure stands in brackish water near the coast. It is a weed in aquatic biotopes.

Management Stems to be used for thatching in Senegal are cut at the base at the start of the dry season and dried in the sun.

Genetic resources and breeding No germplasm collections or breeding programmes of *Schoenoplectus* are known to exist.

Prospects The taxonomic situation of this taxon in tropical Africa is unclear and a revision would be very welcome.

Major references Browning, Gordon-Gray & Ward, 1994; Hoenselaar, Verdcourt & Beentje, 2010; Jansen & Brink, 2003; Simpson & Inglis, 2001; Vanden Berghen, 1988.

Other references Akoègninou, van der Burg & van der Maesen, 2006; Bir, Cheema & Sidhu, 1991; Burkill, 1985; Burkill, 2000; Catarino, Duarte & Diniz, 2001; Hooper & Napper, 1972; Müller, 2005; Roalson, 2008.

Authors M. Brink

SCLEROSPERMA MANNII H.Wendl.

Protologue Trans. Linn. Soc. London 24: 427 (1864).

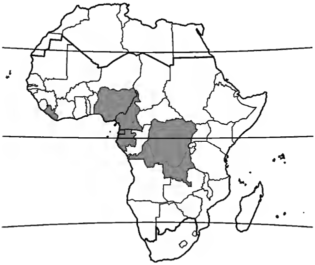
Family Arecaceae (Palmae)

Synonyms *Sclerosperma dubium* Becc. (1934).

Origin and geographic distribution *Sclerosperma mannii* is distributed in Liberia and from south-eastern Nigeria eastward to eastern DR Congo and southward to Cabinda (Angola).

Uses The leaves are widely used for thatching, sometimes together with those of *Raphia* spp. They are also used for making walls. In Gabon they are used for the entrances of Bwiti temples, because of the silvery leaf undersurface. The petioles are recorded to be used in Cameroon for mattresses.

The young fruits are locally eaten. In DR Congo the fruit, the shoot and the soft part of the lower stem are eaten raw as vegetables. In



Sclerosperma mannii – wild

traditional medicine the leaf ash is applied to the eyelid for the treatment of itching eye worm (loa loa filariasis).

Properties No information is available on the properties of thatching material from *Sclerosperma mannii*.

Botany Monoecious, short or acaulescent, clustering, unarmed palm; stem, if evident, very short, fairly stout, ringed with leaf scars. Leaves ascending, very large, divided, juvenile leaves deeply bifid; sheath up to 35 cm long, becoming split opposite the petiole, margins fibrous; petiole slender, 150–300 cm long, channelled adaxially, rounded proximally, becoming triangular distally; rachis 80–150 cm long, continuing in the terminal leaflet, rounded abaxially, ridged adaxially; leaflets 8–17(–24), subopposite to alternate, consisting of several narrow folds, folds 30–45(–63) cm × (3–)6–9(–13) cm, jaggedly toothed at the apex, margin toothed, midvein prominent, upper surface dark green, lower surface glaucous to silvery and with small scales along the veins; terminal leaflet deeply bifid, broadly rhomboid in outline, 30–45 cm × (20–)30–45 cm, with asymmetrical base. Inflorescence solitary, between the leaves, spike-like, many-flowered; peduncle up to 12(–19) cm long, densely hairy; prophyll 2-keeled, becoming fibrous; peduncular bract tubular, 18–25 cm long, forming a fibrous net around the flowers; rachis 10–14 cm long, with at the base a few triads of 2 male flowers and 1 female flower, and distally numerous rows of male flowers; triads subtended by a short, pointed, fibrous bract; distal staminate flowers subtended by small, acuminate bracts. Flowers unisexual, 3-merous, bracteoles present in triads; male flowers in triads more or less pedicellate and asymmetrical, distal ones sessile and symmetrical, sepals distinct, basally imbricate, 3–4 mm long, petals distinct, elliptical, 6–8 mm long, stamens c. 60, filaments short, pistillode absent; female flowers broadly ovoid, larger than male ones, sepals connate in a 3-lobed cupule or margins of 2 sepals distinct and imbricate, petals distinct, asymmetrical, staminodes 6, ovary superior, stigma 3-angled. Fruit a drupe 25–30(–35) mm × 22–29 mm, purplish to black; exocarp thin; mesocarp thin, fibrous; endocarp bony, thick. Seed globose, 15–23(–25) mm × 20–25 mm.

Sclerosperma comprises 3 species and is distributed from Liberia to Angola. *Sclerosperma profiziana* Valk. & Sunderl. is a clustering palm up to 6(–12) m tall, with a stem up to 2 m tall and undivided leaves. It is distributed in Ghana, Congo, DR Congo and Angola. Its leaves are widely used for thatching, especially young leaves not yet damaged by wind. The kernel was formerly used for making rings. *Sclerosperma walkeri* A.Chev. is a short palm with a very short stem and divided leaves, distributed in Gabon and DR Congo. Its leaves are widely used for thatching and locally used for making mats and walls. All *Sclerosperma* species are pleonanthic, i.e. the stems do not die after flowering.

Ecology *Sclerosperma mannii* occurs from sea-level up to 1400 m altitude in the shrub layer of lowland evergreen forest, ranging from forest just behind the mangrove swamp forest, through periodically inundated forest to valley bottom forest at higher elevations. It persists in secondary growth.

Management *Sclerosperma mannii* can be propagated with suckers split from the parent plant.

Genetic resources and breeding *Sclerosperma mannii* has a wide distribution, but occurs highly localised, with many disjunctions. Because of the extent of habitat loss throughout its distribution range there is risk of genetic erosion.

Prospects *Sclerosperma mannii* will remain a useful local source of thatching material in West and Central Africa. Research on the properties of thatching material from *Sclerosperma mannii* might be useful.

Major references Latham, 2004; Terashima, Kalala & Malasi, 1991; Uhl & Dransfield, 1987; van Valkenburg, Sunderland & Couvreur, 2008.

Other references Burkill, 1997; d'Oliveira

Feijão, 1961; Neuwinger, 2000; Raponda-Walker & Sillans, 1961; Russell, 1968; van Valkenburg et al., 2007; Wright, 1901–1902; Yamada, 1999.

Authors M. Brink

SESAMUM TRIPHYLLUM Welw. ex Asch.

Protologue Verh. Bot. Vereins Prov. Brandenburg 30: 185 (1888).

Family Pedaliaceae

Chromosome number $2n$ = c. 26

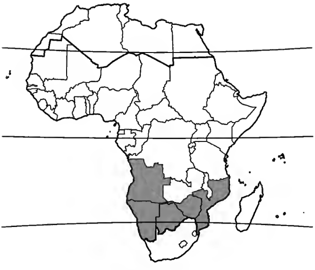
Synonyms *Sesamum gibbosum* Bremek. & Oberm. (1935), *Sesamum grandiflorum* Schinz (1896).

Vernacular names Wild sesame, thunderbolt flower, three-leaved sesame (En).

Origin and geographic distribution *Sesamum triphyllum* is distributed in southern Angola, Namibia, Botswana, Zimbabwe, Mozambique, South Africa and Swaziland.

Uses Although the stems appear rather weak when fresh, they are quite strong when dry. They are used as construction material, for instance for making doors for traditional huts and kraals and for making fish-traps. Dry stems are also used as tinder when using fire-sticks. The seeds are rich in oil and are said to be eaten. When the leaves are crushed, they release a mucilage which can be used as a soap substitute.

Sesamum triphyllum has several uses in traditional medicine. The burnt root mixed with vaseline is applied to snake-bites. A root decoction is said to be effective against chest pains. Women treat menstruation pains with a root decoction or by chewing the roots. Pregnant women suffering abdominal pains and afraid of losing an unborn baby take a root decoction. The leaves mixed with milk are taken as an aphrodisiac. In Namibia inhaling the vapour given off by leaves in boiling water is a treatment of malaria. Among Sotho people in South Africa a mixture of plants, including *Sesamum triphyllum*, is used in the treatment of epilepsy.



Sesamum triphyllum – wild

Production and international trade *Sesamum triphyllum* is only used and possibly traded locally.

Properties While *Sesamum triphyllum* is one of the components of 'sehlare sa seebana', a Sotho medicine against epilepsy, extracts of it tested negative in a test designed to identify compounds with potential activity against epilepsy, while some other species tested positively.

Botany Annual, erect herb up to 2 m tall, bushy or with unbranched stem, glabrous except for the mucilage glands. Leaves heteromorphic; lower leaves 3(–7)-foliate or 3(–7)-partite, central leaflet or lobe longest, 2–10 cm long, and all leaflets or segments up to 2 cm wide; upper leaves simple. Flowers solitary in leaf axils, bisexual, up to 5 cm long; pedicel short; basal nectaries single or in groups of 3–5; calyx 5-partite, deciduous; corolla more or less funnel-shaped, 2.5–5.5 cm long, mauve, bluish or red, limb sub-bilabiate, lower lobe longer; stamens 4; disk annular, regular; ovary superior, subcylindrical, 2-locular. Fruit an oblong capsule c. 40 mm × 5–7 mm, with paper-thin walls, abaxially gibbous at the base, sometimes with inconspicuous ribs, beak 6–8 mm long and distinctly bent outwards, many-seeded. Seeds c. 2.5 mm × 1.5 mm, with 2 conspicuous wings at the base and an apical wing; seedcoat pitted.

In Botswana *Sesamum triphyllum* flowers in January–April(–June), in the Highveld of South Africa in spring and summer. Both self-pollination and cross-pollination by insects occur.

Sesamum comprises c. 20 species, most of which indigenous to tropical Africa. *Sesamum alatum* Thonn., *Sesamum capense* Burm.f. and *Sesamum triphyllum* share several morphological characteristics: a capsule with tapering pointed beak and paper-thin walls, and winged seeds, and they are placed in a separate section *Sesamopteris*.

Ecology *Sesamum triphyllum* occurs at 150–1700 m altitude in grassland and woodland, along roadsides and on stable sand-dunes. It grows on limestone gravel and calcareous soils.

Management *Sesamum triphyllum* only occurs wild.

Genetic resources and breeding *Sesamum triphyllum* is widespread and not in danger of genetic erosion.

Prospects *Sesamum triphyllum* is likely to remain of limited use only. Its relation with other species in section *Sesamopteris* and its intraspecific classification need clarification.

Major references Hyde & Wursten, 2011; Ihlenfeldt, 1988; Merxmüller & Schreiber, 1968; Roodt, 1998; van Wyk & Gericke, 2000.

Other references Bedigian, 2003; Jäger et al., 2005; Kanyomeka, 2003; SEPASAL, 2011f; Zietsman, 1994.

Authors L.P.A. Oyen

SIDA CORDIFOLIA L.

Protologue Sp. pl. 2: 684 (1753).

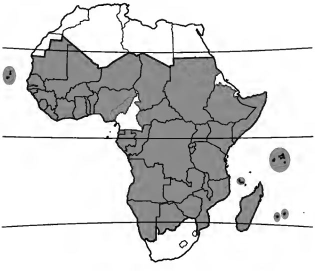
Family Malvaceae

Chromosome number $2n = 28$

Vernacular names Flannel weed, heart-leaf sida, Indian ephedra (En). Balai poilu, herbe à paniers, sida à feuilles en cœur (Fr). Guanxuma (Po). Mgaaga paka (Sw).

Origin and geographic distribution *Sida cordifolia* is a tropical species with 2 subspecies with respectively an African-American and an Asian origin. It is very widespread in tropical Africa and the Asian subspecies is still on the increase in Africa, especially at low altitudes. In India *Sida cordifolia* is cultivated as a fibre plant.

Uses The bark yields fibres that are used for making cordage. Domestication for commercial production of fibres has been attempted in Mozambique and Zimbabwe. In DR Congo the stems are used in basketry. Use of the entire plant or branched stems as brooms is widespread.



Sida cordifolia – wild

In Nigeria the leaves are cooked as a vegetable. The foliage is eaten by livestock throughout West Africa and in northern Nigeria it is valued as a fattening feed for horses. Pounding the leaves yields a glue that is used in Tanzania to seal leaking pots, while in Nigeria this glue is used as an ingredient of arrow-poison.

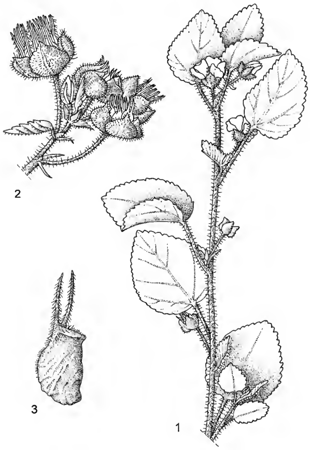
In traditional medicine in Benin the whole plant is used as a cure for cancer and leukaemia, the seeds are a cure for infections and the roots cure urinary tract problems and fever. The powdered whole plant is applied to open wounds of horses in Niger. In Senegal, Côte d'Ivoire, Burkina Faso, Burundi, Kenya, Papua New Guinea and the Philippines the leaves are taken as a cure for dysentery. The pounded leaves are applied as a poultice to sprains and swellings and a leaf decoction is drunk for control of intestinal worms. In DR Congo a leaf infusion is given to children in case of rheumatism, lung disorders and fever. In Rwanda the leaf extract is used for curing pneumonia and syphilis. In Mauritius plant sap is diluted and drunk to relieve colic and a leaf decoction is a cure for cystitis, and is used as an astringent and diuretic. To cure eye inflammation a root macerate is applied to the eyelids in Burkina Faso, while in Tanzania a root preparation is applied and in Malaysia the leaves are applied for this purpose. The juice of the whole plant pounded with a little water is given for spermatorrhoea. In the Central African Republic and in Kenya the root extract is drunk to induce abortion. Women chew the bark to encourage menstruation. An infusion of the roots is given for diseases such as hemiplegia and facial paralysis, for asthma as well as for disorders of the blood and bile. Powdered root bark is given with milk and sugar to persons suffering from leucorrhoea. The seeds are considered to have aphrodisiac properties and are used as a cure for gonorrhoea, cystitis, and colic.

Production and international trade *Sida cordifolia* is traded for medicinal purposes at the local level and via Internet.

Properties The roots of *Sida cordifolia* are very mucilaginous, and contain the chinazoline alkaloid vasicine (peganine). Aerial parts can contain ephedrine, pseudo-ephedrine and vasicine. The stem bark of plants from different provenances within India yielded in some cases zero vasicine while in others vasicine was the main alkaloid. Ephedrine and pseudoephedrine varied between provenances in the same way. The seeds contain up to 0.3% alkaloids, mainly ephedrine, and 30% oil containing the cocarcinogenic acid coronaric acid. Pharmacological effects of extracts of the plant include: antiprotozoal activity of an ethanolic extract against *Entamoeba histolytica* and decrease of blood pressure in cats and dogs. Furthermore, an extract of the aerial parts and the roots show analgesic, anti-inflammatory and hypoglycaemic activities. The methanolic and aqueous extracts of whole plants showed significant activity against CCl_4-, paracetamol- and rifampicin-induced hepatotoxicity.

Adulterations and substitutes Decoctions of the roots and leaves of *Abutilon*, *Triumfetta* and *Urena* species are used as an emollient in the same way as those of *Sida* species.

Description Erect annual or perennial herb or shrublet up to 1.5 m tall; stems with stellate hairs, with or without long, simple hairs, becoming glabrous. Leaves alternate, simple; stipules filiform, 2.5 mm long; petiole 1–5.5 cm long; blade broadly ovate to round, 3–8 cm × 1–8 cm, cordate to rounded at the base, acute to rounded at the apex, margin toothed, upper surface stellate-pubescent, lower surface thinly to thickly velvety tomentose. Flowers axillary and solitary or in clusters at the end of lateral branches, or forming terminal panicles, bisexual, regular; pedicel 4–20 mm long, jointed near apex; epicalyx absent; calyx 5-lobed to the middle, 4–8 mm long; petals 5, yellow, 6–8 mm long; staminal column c. 3 mm long, hairy; ovary superior. Fruit a subglobose schizocarp of 8–10 follicle-like mericarps; mericarps 3–5 mm long, lower part reticulately sculptured, with a pair of 3–6 mm long, retrorsely armed awns, black, 2–3-seeded. Seeds c. 2.5 mm in diameter, glabrous except for some short hairs towards the hilum.



Sida cordifolia – 1, flowering and fruiting branch; 2, fruits; 3, mericarp.
Redrawn and adapted by Achmad Satiri Nurhaman

Other botanical information *Sida* comprises c. 200 species, distributed in the tropics and subtropics. It has been suggested that on the basis of the morphological and geographical diversity, *Sida* could be of polyphyletic origin. It is morphologically fairly close to *Abutilon* and *Wissadula*, and all lack the epicalyx. Two subspecies are distinguished in *Sida cordifolia*. The typical subspecies has long simple spreading hairs and originates in Asia where it is mainly found in coastal areas. This subspecies has become naturalized in many African countries and is the sole subspecies occurring in Somalia. *Sida cordifolia* subsp. *maculata* (Cav.) Marais lacks the long simple spreading hairs and is native to tropical Africa and America and on the increase in tropical Asia.

Several other species of *Sida* produce useful fibres. *Sida alba* L. is a widely distributed weedy species of tropical Africa, South Africa, Arabia, India and America and is often found in disturbed places. The bark fibre is used for cordage, the stems are used for cleaning teeth and stems tied together are used as brooms. In Malawi the stems are used for tying in roof construction and the leaves are cooked and eaten as a vegetable. The leaves are browsed by goats (Kenya) and horses and donkeys (Sudan). In Senegal an infusion of leaves and roots is drunk to cure dysentery and to increase the energy of recovering patients. In Kenya the leaves are chewed and the sap is swallowed after a snakebite. In Benin a mixture of pounded leaves with shea butter is rubbed on a painful lower-back.

Sida linifolia Juss. ex Cav. is distributed from

Mauritania and Senegal to the Central African Republic, DR Congo, Uganda, Tanzania and Angola, as well as in tropical America and Kerala (India). In Gabon the stems are used for brooms. In Côte d'Ivoire the whole plant is considered as a cure for male sterility. Its aerial parts appear to play a role in women's health as a contraceptive, abortifacient and as a cure for uterine fibroma. In Kenya women chew the root bark daily during pregnancy to ease the expulsion of the placenta. Wounds and ulcers are treated in Nigeria with dressings of stem and root paste. In Togo leaf pulp is applied to abscesses and leaf sap is rubbed into the skin rash caused by chickenpox. In DR Congo dressings of leaf paste are applied for skin diseases. A leaf decoction is drunk in Togo to relieve lumbar pain and in Benin as a cure for jaundice. Twig sap is drunk as a remedy for anxiety.

Sida urens L. ('nettle-leaved sida') is widely distributed in tropical Africa, tropical America and the West Indies and has been introduced in Réunion and New Caledonia. The bark yields a good quality fibre. The fresh leaves, alone or in mixtures, are taken as an aphrodisiac in Côte d'Ivoire.

Anatomy In a transverse section of the stem, the bast fibres occur in a circle of rectangular wedges, with c. 28 fibre bundles per wedge. The bundles are square, rectangular to irregular in shape, but uniformly distributed, with c. 24 cells per bundle.

Growth and development *Sida cordifolia* is considered a noxious weed in many crops and pastures, because of the tough stems and the ability to grow fast from seed. When water is available it flowers throughout the year and flowers open in the morning and wither in the afternoon. In Benin *Sida cordifolia* flowers and fruits from August to November.

Ecology *Sida cordifolia* grows on drier sandy locations, from sea-level up to 1700 m altitude. It is a weed of cultivation, fallow and roadsides, often locally abundant.

Propagation and planting *Sida cordifolia* produces large amounts of seed and can be easily propagated by seed.

Management There is a vast amount of literature on the control of *Sida cordifolia* as a weed but little is published on cultivation for fibre production.

Diseases and pests Mycoplasma-type organisms cause yellow symptoms on *Sida cordifolia* in Burkina Faso. It is a common host for several nematodes, including *Meloidogyne incognita*.

Harvesting In tropical Africa *Sida cordifolia* is nowadays only collected from the wild and usually whole plants are harvested, including the roots.

Yield Fibre yields of 730 kg/ha have been recorded in DR Congo. In experiments in Rwanda in the 1950s fibre yields of 600–860 kg/ha were obtained, with the fresh, defoliated stems yielding 4.0–4.2% fibre after 6 days of retting.

Handling after harvest The fibre can be extracted by retting the stem in water. Fresh use of *Sida cordifolia* as a medicinal plant is most common but drying and subsequent storage before use is practiced as well.

Genetic resources *Sida cordifolia* is widely distributed, also as a weed, and is locally rather common in open and disturbed areas. It is not likely to succumb to the threats of genetic erosion. The extreme variation in properties, especially in content of different alkaloids, would make it imperative that this is taken up in a taxonomic study if the species is to be used more rationally for medicinal purposes.

Prospects *Sida cordifolia* will only continue to play a role locally in the production of fibres. It might be of interest as a local industrial source of the alkaloid ephedrine. However, ephedrine can also be produced synthetically, and its use in medicine is rapidly becoming obsolete.

Major references Balu Perumal, 2001b; Boiteau, Boiteau & Allorge-Boiteau, 1999; Burkill, 1997; Hochreutiner, 1955; Kirby, 1963; Lejeune, 1953; Marais, 1984; Verdcourt & Mwachala, 2009.

Other references Adam, Echard & Lescot, 1972; Akoègninou, van der Burg & van der Maesen, 2006; Bhat, Etejere & Oladipo, 1990; Brochmann & Rustan, 2002; Bruneton, 1995; Exell & Meeuse, 1961; Gurib-Fakim, Guého & Bissoondoyal, 1996; Kanth & Diwan, 1999; Maiti, 1979; Maiti, 1997; Marais & Friedmann, 1987; Muanza et al., 1995; Neuwinger, 1998; Neuwinger, 2000; Nwobodo et al., 1996; Perrotta, Coody & Culmo, 1996; Rao & Mishra, 1988; Ugborogho, 1983; van Borssum-Waalkes, 1966; Williamson, 1955.

Sources of illustration Marais & Friedmann, 1987; Thulin, 1999a.

Authors H.P. Bourobou Bourobou

Based on PROSEA 12(2): Medicinal and poisonous plants 2.

SIDA RHOMBIFOLIA L.

Protologue Sp. pl. 2: 684 (1753).

Family Malvaceae

Chromosome number $2n = 14, 18, 28, 36$.

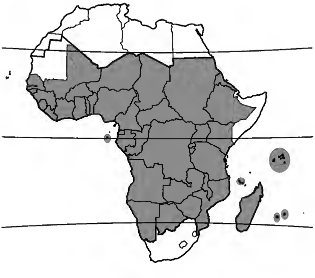
Vernacular names Queensland hemp, sida hemp, Cuba jute, arrow-leaf sida, broom jute sida (En). Chanvre du Queensland, herbe dure (Fr).

Origin and geographic distribution *Sida rhombifolia* is widely distributed in the tropics and occurs in almost all countries of tropical Africa. In Niger, DR Congo and the Central African Republic it is cultivated as a fibre crop, and in India, Australia and the Americas as well.

Uses The bark of *Sida rhombifolia* yields fibres that are used in the same way as those of jute (*Corchorus* spp.). In Niger the fibres are used to make fishing-lines and nets and in the Central African Republic for making large hunting-nets. The stems are woven to produce wattle-work doors, and in Gabon and Kenya they are used for cleaning the teeth. The whole plants are used as brooms in DR Congo, the Central African Republic and Gabon.

The leaves and shoots are used as a vegetable in South Africa and South America. In Indo-China, the roasted leaves are used for making a refreshing drink. Like most *Sida* species, *Sida rhombifolia* is appreciated as a fodder. In East Africa, the wood-tar of *Sida rhombifolia* is used as a dye and in India it is used for blackening teeth. The leaves are used as a soap-substitute in Gabon and Kenya.

In traditional African medicine decoctions of the roots and leaves are widely used as emollients. The leaves or the leaf sap are applied to the skin as an antiseptic and to treat abscesses, ulcers and wounds, for instance in Equatorial Guinea, Gabon, DR Congo, Tanzania and Madagascar. The roots and leaves (DR Congo) or the leaves alone (Gabon) are used as an abortifacient. In Cameroon a watery maceration of the leaves is drunk as an antihypertensive agent, as a sedative, against sexually transmitted diseases and to cure diarrhoea. The same cure for diarrhoea is used in DR Congo where it is also thought to help overcome general stomach complaints and dysentery. Leaves and roots are used in Senegal, the Central African Republic and Madagascar for respiratory diseases like asthma, bronchitis, dyspnoea and pneumonia. The flowers are applied to wasp stings or eaten to ease labour pains. In the Philippines and Indonesia a paste of the leaves mixed with coconut oil is applied to scurf and itch. In Malaysia the plant has been used to treat pulmonary tuberculosis. In Fiji and Papua New Guinea the leaves are used to treat strained muscles, labour pains and migraine. Roots are chewed against toothache in Cameroon and Indonesia, and against dysentery in South-East Asia.



Sida rhombifolia – wild and planted

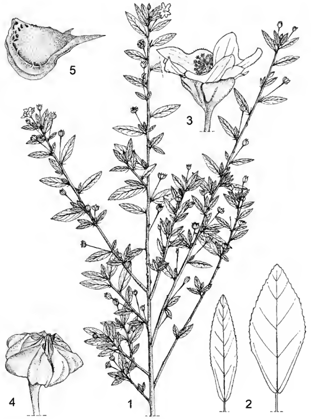
Production and international trade In tropical Africa *Sida* species are used and traded at the local level only, for medicinal purposes. Chinese and Ayurvedic herbalists stock *Sida rhombifolia* plants and trade them through Internet.

Properties The fibre extracted from the bark of *Sida rhombifolia* is white, supple, soft, lustrous and has an even texture. After careful processing it can be spun with silk. Although it is finer and less strong than the fibre of jute (*Corchorus* spp.), it has similar properties and can serve as a substitute. The ultimate fibres are 0.8–2.3 mm long and 15–25 μm wide. Bast fibre from Sierra Leone contained 74.2% cellulose and 12.7% lignin, and fibre from India 74.8% cellulose and 10.2% lignin. The seeds contain 16.9% oil.

The leaves and roots contain ephedrine. Ephedrine has been used in China for centuries to treat asthma and bronchitis. Roots also contain flavonoids, tannins, steroids, resins and triterpenoids. In tests for toxicity aqueous extracts were shown to be practically nontoxic. The ethanolic extract of the plant depresses the activities of the smooth muscles of isolated guinea-pig ileum. Macerations of the leaves showed antimicrobial activity against *Citrobacter diversus*, *Escherichia coli*, *Escherichia paracoli*, *Klebsiella pneumoniae*, *Pseudomonas* *aeruginosa*, *Salmonella enteritidis*, *Shigella flexneri* and *Staphylococcus aureus*. Methanolic plant extracts show antimicrobial activity against *Aspergillus ochraceus*, *Candida albicans*, *Candida intermedia*, *Cunninghamella elegans*, *Pseudomonas aeruginosa* and *Staphylococcus aureus*. Ethanolic extracts of the leaves and aqueous extracts of the roots showed activity against *Pseudomonas aeruginosa* and *Staphylococcus aureus*. Root extracts showed significant wound healing properties. Finally, in a screening assay, a leaf extract exhibited anticancer activity and anti-HIV activity in 60 human cell lines tested.

Adulterations and substitutes Decoctions of the roots and leaves of *Abutilon*, *Triumfetta* and *Urena* species are used as emollients in the same way as those of *Sida* species. Raw material of *Ephedra* species for the production of herbal medicine and pure ephedrine is produced in China on a large scale. In 2007, US$13 million worth of ephedrine for export was produced from 30,000 t of raw material from *Ephedra* species.

Description Perennial, erect herb or shrublet up to 2(–3) m tall; stems with stellate hairs or densely covered with soft, curly hairs. Leaves alternate, simple; stipules linear, 3–12 mm long; petiole up to 2.5 cm long; blade oblanceolate to ovate, 0.5–13 cm × 0.5–6 cm, cuneate to rounded at the base, acuminate to rounded at the apex, margin serrate, upper surface stellate-pubescent, with simple hairs or glabrous, lower surface more densely hairy than upper surface. Flowers axillary and solitary or clustered at the end of lateral branches, bisexual, regular; pedicel up to 3.5(–6) cm long, jointed near apex; epicalyx absent; calyx 10-ribbed at base, 5-lobed to the middle, 5–8 mm long; petals 5, 6–8 mm long, white, pale yellow or yellowish pink; staminal column 1–3 mm long, hairy, with stalked glands; ovary superior. Fruit a subglobose schizocarp of (8–)9–12(–14) follicle-like mericarps; mericarps 3–3.5 mm long, smooth or reticulately sculptured, with 1–2 short or long awns or none, black, 2–3-seeded. Seeds flattened, kidney-shaped, c. 2 mm in diameter, dark brown to black, glabrous.



Sida rhombifolia – 1, flowering and fruiting branch; 2, types of leaves; 3, flower; 4, capsule, 5; seed.
Source: PROSEA

Other botanical information *Sida* comprises c. 200 species, distributed in the tropics and subtropics. It has been suggested that on the basis of the morphological and geographical diversity, *Sida* could be of polyphyletic origin. It is morphologically fairly close to *Abutilon* and *Wissadula*, and all lack the epicalyx.

Anatomy In a transverse section of the stem the bast fibres occur in a circle of rectangular wedges, with c. 42 fibre bundles per wedge. The bundles are square, rectangular to irregular in shape, but uniformly distributed, with c. 14 cells per bundle.

Growth and development Because of the tough stems and the ability to grow fast from seed, *Sida rhombifolia* is considered a noxious weed in many crops and pastures. Overgrazing will cause a rapid increase as the stems are unpalatable to cattle. It has well developed roots and grows well even under dry conditions. In shaded places the leaves remain smaller and are less hairy than those growing in exposed conditions.

Ecology *Sida rhombifolia* is a ruderal species, mostly found close to settlements, along roads and paths, and in forest edges and clearings. It is also often found on river banks, in riverine forest and in overgrazed grassland and bushland and occurs at 200–2800 m altitude.

Propagation and planting The majority of the seeds of *Sida rhombifolia* are dormant for 12–24 months after maturity. Germination was

8% at a temperature of 35°C and was increased to 62% by a hot water (80°C) pretreatment of 10 minutes followed by a cold water (5°C) pretreatment of 10 minutes. Treatment of seed by soaking for 25 minutes in H_2SO_4 resulted in a germination of 100%. The optimum temperature range for germination is 25–35°C.

Management Although cultivation of *Sida rhombifolia* as a fibre crop has been taken up in several countries, few details have been published. Along the river Niger it is cultivated after retreat of flood-waters. In the Central African Republic it is planted as a border crop in arable fields and the crop cycle is 4.5–5 months.

Diseases and pests Mycoplasma-type organisms cause yellow symptoms on *Sida rhombifolia* in Burkina Faso. In Australia the beetle *Calligrapha pantherina*, native to Mexico, has been released as a biological control agent for the control of weedy *Sida* spp. The beetle is specific to *Sida* and it leads to complete defoliation of plants.

Harvesting Harvesting of *Sida rhombifolia* is mostly done from the wild.

Yield In DR Congo fibre yields of 1300 kg/ha have been recorded. In experiments in Rwanda in the 1950s fibre yields of 240 kg/ha were obtained, with the fresh, defoliated stems yielding 4.0% fibre after 6 days of retting.

Handling after harvest Extraction of the fibre is difficult, but these problems should be easily overcome through experimentation. In the Central African Republic the stems are left to dry for 10–12 days and retting in water takes another 20 days. In South Africa the leaves are preserved by drying before storing to be consumed later as a vegetable.

Genetic resources *Sida rhombifolia* is widely distributed, also as a weed, and locally rather common in open and disturbed areas. Therefore it is not likely to succumb to the threats of genetic erosion. Small germplasm collections are kept in Russia and in the United Kingdom.

Prospects *Sida rhombifolia* will only continue to play a role locally in the production of fibres. It might be of interest as a local industrial source of the alkaloid ephedrine. However, ephedrine can also be produced synthetically, and its use in medicine is rapidly becoming obsolete.

Major references Balu Perumal, 2001b; Burkill, 1997; Kirby, 1963; Muanza et al., 1995; Neuwinger, 2000; Raponda-Walker & Sillans, 1961; Verdcourt & Mwachala, 2009.

Other references Akoègninou, van der Burg & van der Maesen, 2006; Balakrishnan et al., 2008; Bhat, Etejere & Oladipo, 1990; Brugés & Reguero-Reza, 2007; Dubois, 1951; Kambu et al., 1989; Lejeune, 1953; Lonsdale, Farrell & Wilson, 1995; Maiti, 1979; Maiti, 1997; Norman, 1937; Noumi, Houngue & Lontsi, 1999; Perrotta, Coody & Culmo, 1996; Robinson & Johnson, 1953; Seal & Gupta, 1998; Shackleton et al., 1998; Ugborogho, 1983; van Borssum-Waalkes, 1966; Verdcourt, 2004; Vollesen, 1995a.

Sources of illustration Balu Perumal, 2001b.

Authors C.H. Bosch

Based on PROSEA 12(2): Medicinal and poisonous plants 2.

SOYAUXIA FLORIBUNDA Hutch.

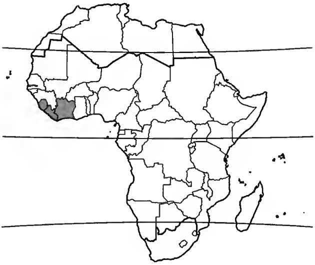
Protologue Kew Bull. 1915: 44 (1915).

Family Medusandraceae (APG: Peridiscaceae)

Origin and geographic distribution *Soyauxia floribunda* is distributed in Gambia, Sierra Leone, Liberia and Côte d'Ivoire. Records of the species from Gabon are almost certainly based on misidentifications.

Uses The twigs of *Soyauxia floribunda* are used in Sierra Leone as chew-sticks for children to clean the teeth. The flexible stems are made into hoops for fishing nets. To make a thorn come out of a wound, a poultice made of roasted bark is applied to the wound.

Botany Shrub or small tree up to 12(–18) m tall; bole fluted, inner bark thin, granular, red; crown spreading; young branches densely hairy, twigs flat. Leaves arranged spirally,



Soyauxia floribunda – wild

simple and entire; stipules paired, oblong, soon falling; petiole short; blade oblong to elliptical, 8–27 cm × 3–8 cm, rounded at base, long acuminate at apex, leathery, glossy, glabrous beneath when mature, pinnately veined with more than 12–16 pairs of distinct lateral veins. Inflorescence an axillary or terminal raceme with flowers scattered, up to 12 cm long. Flowers bisexual, regular, 5-merous; pedicel very short; sepals ovate, c. 4 mm long, persistent in fruit, glabrous but for some short hairs at base; petals free, white, as long as sepals; corona short, tubular; stamens many, filaments long and thin, anthers 4-celled; ovary superior, 1-celled, styles 3, long and exserted. Fruit an oblong, sessile, 3-valved capsule 12–18 mm long, 1-seeded. Seed trigonous, black, c. 15 mm long. Seedling with hypogeal germination; first 2 leaves opposite, simple.

Soyauxia floribunda flowers in April–September and fruits in August–February.

Soyauxia comprises about 6 species, distributed in West and Central Africa. It has been placed in *Flacourtiaceae* and *Passifloraceae* and resembles some *Euphorbiaceae*. More recently it has been included in *Medusandraceae*, but the most modern approach is to place it in *Peridiscaceae*, together with 2 genera from tropical America. The closely related *Soyauxia gabonensis* Oliv. is a small tree of up to 3 m tall that produces edible fruits, and is found in rainforest in Nigeria, Cameroon and Gabon.

Ecology *Soyauxia floribunda* occurs from sea-level up to 700 m altitude, most often in rainforest, rarely in semi-deciduous forest; it is conspicuous in forest regrowth. In Côte d'Ivoire *Soyauxia floribunda* is exclusively found in *Diospyros-Mapania* forest on soils derived from schists. On the sandy soils of the south it is absent and northward it extends up to the 1700 mm isohyet.

Management The 1000-seed weight is about 500 g.

Genetic resources and breeding *Soyauxia floribunda* is not present in any germplasm collection. The species apparently has a wide distribution and only widespread loss of habitat would form a serious threat.

Prospects *Soyauxia floribunda* will remain useful only locally.

Major references Aubréville, 1959c; Burkill, 1997; Keay, 1958e; Lisowski, 2009.

Other references Bayer, 2007; Brenan, 1953; de la Mensbruge, 1966; Hawthorne & Jongkind, 2006; Normand, 1960; Normand & Paquis, 1976; Nyanayo, 1986; Portères, 1974; Saville & Fox, 1967; White, 1978.

Authors C.H. Bosch

SPARRMANNIA RICINOCARPA (Eckl. & Zeyh.) Kuntze

Protologue Revis. gen. pl. 3(2): 26 (1898).

Family Tiliaceae (APG: Malvaceae)

Chromosome number $2n = 16$

Synonyms *Sparrmannia subpalmata* Baker (1883), *Sparrmannia macrocarpa* Ullbr. (1914).

Origin and geographic distribution *Sparrmannia ricinocarpa* is distributed from eastern Cameroon eastward to Sudan, Eritrea and Ethiopia and southward to South Africa. It also occurs in Madagascar and Réunion.

Uses The bark yields a good fibre that is locally used for making rope and textiles. The pollen and nectar are collected by bees.

Botany Small shrub, herb or scrambler up to 3 m tall, much-branched; stems slender, with spreading simple hairs and shorter stellate hairs. Leaves alternate, simple; stipules linear-lanceolate, up to 1.5 cm long; petiole 1–8(–9) mm long, hairy; blade ovate in outline, deeply 3–7-lobed, 2–19 cm × 1–18 cm, base cordate, cordate-sagittate or truncate, apex acuminate to cuspidate, margin wavy and toothed, often with secondary lobing, 5–7-veined from the base, with stellate or simple hairs or both, lobes triangular to ovate, the central one longest and acuminate. Inflorescence composed of extra-axillary or leaf-opposed umbelliform cymes, 3–25-flowered; peduncle 1–10 cm long, hairy; bracts subulate to lanceolate, up to 1.5 cm long, hairy. Flowers bisexual, regular, 4-merous; pedicel 1–2.5 cm long, articulate in upper half, more densely hairy above articulation than below; sepals free, linear-oblong, 8–15 mm × 2–5 mm, green outside, white or purple inside, hairy, deciduous; petals oblanceolate to oblanceolate-oblong, 8–16(–19) mm × 3.5–9(–10) mm, white, pink or purple, glabrous; androgynophore absent; stamens c. 50, 5–8 mm long, filaments yellow, anthers yellow or purple; ovary superior, 2.5 mm long, style 3–8 mm long. Fruit an ellipsoid capsule 8–25(–30) mm × 8–20 mm, 4–5-locular, loculicidally dehiscent from apex, brown, sparsely to densely stellate-hairy, with rigid purplish bristles up to 1(–3) cm long ending in a sharp straight point, many-seeded. Seeds ellipsoid-biconic, 2.5 mm × 1.5 mm, dark brown.

In Kenya *Sparrmannia ricinocarpa* flowers more or less throughout the year.

Sparrmannia is a taxonomically difficult genus with an uncertain number of species, but with at least 2 species in mainland Africa and 2 in Madagascar. In the present treatment *Sparrmannia macrocarpa* and *Sparrmannia subpalmata* are considered synonyms of *Sparrmannia ricinocarpa*, but some authors consider them distinct species. The bark fibre of *Sparrmannia discolor* Baker, a shrub up to 3 m tall and endemic to Madagascar, is used for cordage.

Ecology *Sparrmannia ricinocarpa* occurs at 700–3350(–3500) m altitude in grassland, woodland, riverine forest, forest edges and clearings and secondary forest. It is also present in wasteland and along roads, and persists in hedges and *Eucalyptus* plantations.

Management *Sparrmannia ricinocarpa* can be propagated using seed or cuttings. Cuttings should be taken from the previous season's growth. In Madagascar the bark of *Sparrmannia ricinocarpa* and many *Dombeya* and *Grewia* species was formerly beaten on a mallet to obtain bark-cloth. As technology evolved, fibres were extracted by crushing the bark, after which they were combed or scutched, making them suitable for spinning and weaving.

Genetic resources and breeding In view of its wide distribution, *Sparrmannia ricinocarpa* seems not threatened by genetic erosion.

Prospects *Sparrmannia ricinocarpa* yields a fibre, which is locally used for rope and textiles. The fibre is recorded to be of good quality, but detailed and quantitative information on the fibre properties is lacking. Research in this area may be warranted.

Major references Beentje, 1994b; Vollesen & Demissew Sebsebe, 1995; Whitehouse et al., 2001; Wilczek, 1963.

Other references Bosser, 1987; Capuron, 1963; Latham, 2007; Nichols, 2005; Vololomboahangy, 2004; Wild, 1963; Wild, 1984.

Authors M. Brink

SPHAGNUM CUSPIDATUM Ehrh. ex Hoffm.

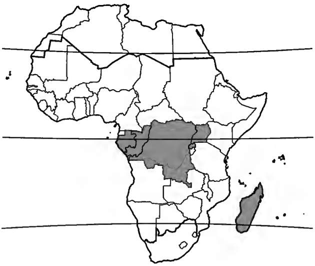
Protologue Deutschl. Fl. 2: 22 (1796).

Family Sphagnaceae

Chromosome number $n = 19 + 2$

Synonyms *Sphagnum gabonense* Warnst. (1911).

Vernacular names Feathery bog-moss, toothed sphagnum (En). Sphaigne (Fr).



Sphagnum cuspidatum – wild

Origin and geographic distribution *Sphagnum cuspidatum* occurs on all continents. In Africa it is recorded from Gabon, Congo, DR Congo, Rwanda, Uganda and Madagascar.

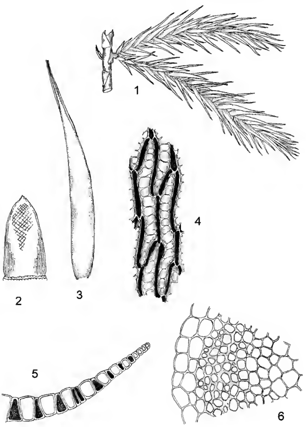
Uses In Gabon *Sphagnum cuspidatum* moss is collected and used to fill cushions and mattresses. *Sphagnum* mosses, including *Sphagnum cuspidatum*, are used widely in the floral industry for wreaths or to line hanging baskets. Because of its peculiar leaf structure, which enables the plant to absorb and store water many times its own weight, *Sphagnum* is often used in potting new plants. Mixed with partially decomposed organic matter, it is a good germinating medium for seeds. *Sphagnum* is occasionally used in boxing fragile commodities. It has been used as antiseptic wound dressing to stop bleeding.

In temperate countries, *Sphagnum* bogs have been exploited as a source of peat for fuel. For this purpose, the dead, partially decomposed material accumulating in the lower levels in the peat bog is used. *Sphagnum* peat is also widely used by gardeners for soil amendment.

Production and international trade *Sphagnum* is traded in temperate regions and on a small scale in the tropics, e.g. in South-East Asia; trade in tropical Africa is probably insignificant.

Properties In tests *Sphagnum* extracts showed antibiotic activity against gram-positive bacteria.

Botany Dioecious, slender and weak-stemmed moss, moderate-sized, growing in greenish tussocks, feather-like in submerged plants; stem with a cortex of 2–3 cell layers, clearly differentiated from the greenish central cylinder; branches in fascicles of 3–5(–6). Stem



Sphagnum cuspidatum – *1, part of stem with branch fascicle; 2, stem leaf; 3, branch leaf; 4, part of transverse section of branch leaf; 5, cells on dorsal surface of branch leaf; 6, part of transverse section of stem.*
Source: PROSEA

leaves triangular, 1–1.5(–2) mm × 0.5–1 mm, acute to rounded at apex; branch leaves narrowly ovate-lanceolate, 1.5–4 mm × c. 0.5 mm, often slightly toothed and inrolled near apex. Leaf cells in a single layer, consisting of 3 main types: elongated border cells, narrow living green cells and inflated dead hyaline cells; in branch leaves green cells in section triangular or trapezoid and exposed on dorsal surface, hyaline cells with wall fibrils and up to 10 pores. Capsule globose, borne on top of a transparent stalk, containing numerous yellowish brown spores.

Sphagnum species generally grow slowly. Growth may be slightly over 5 cm/year, but it is much less at higher altitudes. Ripe capsules shrink in dry weather to build up internal pressure, blowing off the lid and ejecting the spores, but this mechanism frequently does not work, and then the lid merely falls off or the capsule disintegrates.

Sphagnum is a genus of at least several hundreds of species; it has a worldwide distribution. In Africa about 30 species occur.

Ecology *Sphagnum cuspidatum* is dominant, floating in bog pools and inundated depressions; it grows on wet humus in forests and at bases of trees forming a hummock-hollow complex adjacent to bog mats.

In wetlands where submerged *Sphagnum* mosses are the dominant plants, they consume methane through symbiosis with partly endophytic methanotrophic bacteria, leading to highly effective in situ methane recycling preventing large-scale methane emission into the atmosphere. The bacteria are present in the hyaline cells of the plant.

Management In Gabon the plants are collected in the dry season and dried in the sun before being used for filling. A disease in humans called cutaneous sporotrichosis causing ulcerous skin lesions is caused by a fungus that may be present in *Sphagnum* moss. This disease is known in the United States, but may occur elsewhere. It is advised that people who regularly work with fresh or dried *Sphagnum* wear gloves and long sleeves to avoid direct contact with cuts or scrapes in the skin.

Genetic resources and breeding Market consumption of *Sphagnum* mosses depends on wild populations. This creates a perennial risk of overexploitation of this ecologically important plant.

Prospects Peat moss will probably remain a plant product of very limited importance in Africa. In temperate areas it will remain an important source of potting material, but the absence of possibilities of commercial cultivation and the growing need to protect its habitat in wetlands may become limiting factors for its production.

Major references Demaret, 1954; Eddy, 1985; Gao Chien & Crosby, 1999–2002; O'Shea, 2003; Tan, 2003.

Other references Backius, 1989; Baker & Boatman, 1990; Bryan, 1955; Burkill, 2000; Corley et al., 1981; Crosby, Schultze-Motel & Schultze-Motel, 1983; Maisels, Cheek & Wild, 2000; Raghoebarsing et al., 2005; Strack & Waddington, 2008; Walker, 1950.

Sources of illustration Tan, 2003.

Authors L.P.A. Oyen

STACHYANTHUS OCCIDENTALIS (Keay & J.Miège) Boutique

Protologue Bull. Jard. Bot. Etat 29: 431 (1959).

Family Icacinaceae

Chromosome number $2n = 40$

Synonyms *Neostachyanthus occidentalis* Keay & J.Miège (1955).

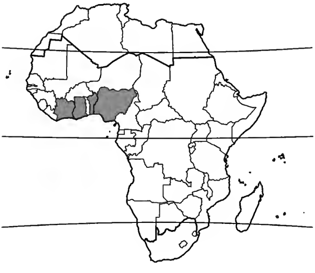
Origin and geographic distribution *Stachyanthus occidentalis* is distributed from Côte d'Ivoire to Nigeria, but has not been recorded for Togo.

Uses In Ghana the stems are locally used for tying in construction.

Botany Dioecious, shrubby liana up to 10 m long; stem very thin, 5–6(–12) mm in diameter, rusty brown; branchlets sparingly pubescent or glabrous. Leaves alternate, simple, entire; stipules absent; petiole sparingly pubescent or glabrous; blade elliptical-ovate to oblong-obovate, 9–20 cm × 4–10 cm, base obtuse, rounded or cordate, apex acuminate, midvein and main lateral veins yellow or orange beneath. Inflorescence a raceme 15–30 cm long. Flowers 4–5-merous, greenish white; petals 4–5, c. 0.5 mm long, fused at the base; petals c. 3 mm long; male flowers with 4–5 stamens with yellow anthers, ovary reduced; female flowers with superior, 1-locular ovary. Fruit c. 1 cm long, flattened, with caducous hairs, red-orange when ripe, with persistent calyx, pulp fleshy, 1-seeded. Seedling with epigeal germination.

Stachyanthus comprises c. 5 species, distributed in tropical Africa.

The lianescent branches of *Stachyanthus occidentalis* may be prolongations of the juvenile, erect stems, but mostly they develop from stolons arising from the axils of the cotyledons or the first leaves of the juvenile plant. *Stachyanthus occidentalis* flowers in February–October, and fruits in July–February.



Stachyanthus occidentalis – wild

Ecology *Stachyanthus occidentalis* occurs in semi-deciduous forest, forest swamps, savanna, along dams and roads, in farm regrowth, and sometimes as a weed; it is locally common.

Genetic resources and breeding *Stachyanthus occidentalis* has a restricted distribution, but it is locally common and present in a range of habitats, including disturbed locations.

Prospects *Stachyanthus occidentalis* will probably remain of occasional local use only.

Major references Akoègninou, van der Burg & van der Maesen, 2006; Burkill, 1994; Irvine, 1961; Keay, 1958c; Keay & Miège, 1955.

Other references Cremers, 1974; Hallé, Oldeman & Tomlinson, 1978; Kokou et al., 2000.

Authors M. Brink

STACHYOTHYRSUS STAPFIANA (A.Chev.) J.Léonard & Voorh.

Protologue Bull. Jard. Bot. Etat 34: 422 (1964).

Family Caesalpiniaceae (Leguminosae - Caesalpinioideae)

Synonyms *Oxystigma stapfiana* A.Chev. (1911), *Kaoue stapfiana* (A.Chev.) Pellegr. (1933).

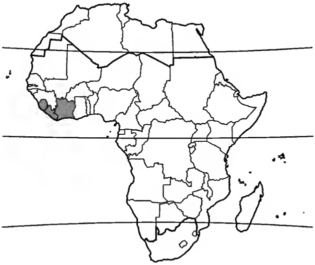
Vernacular names Red pine (En).

Origin and geographic distribution *Stachyothyrsus stapfiana* occurs in Sierra Leone, Liberia and Côte d'Ivoire.

Uses The large leaves are used for thatching. The wood is occasionally used as timber.

Properties The heartwood is yellow to brown and distinctly demarcated from the pink-grey or whitish sapwood. The grain is mostly straight, texture medium. The wood is fairly heavy, with a density of about 750 kg/m^3 at 12% moisture content. At 12% moisture content, the modulus of rupture is about 98 N/mm^2, modulus of elasticity 16,400 N/mm^2, compression parallel to grain 59 N/mm^2, Janka side hardness 7650 N, and Janka end hardness 9070 N. The wood is easy to work, finishes smoothly and polishes well, but it is liable to decay and attacks by termites and other insects. Furthermore, logs of useful sizes are not common, because the tree usually has a poor bole shape.

Botany Evergreen, small to fairly large tree up to 30 m tall; bole branchless for up to 16 m,



Stachyothyrsus stapfiana – wild

up to 60 cm in diameter, with sharp root ridges and sometimes aerial roots; outer bark fairly smooth, grey or brown, finely lenticellate, inner bark fibrous, brown, somewhat sticky; crown rounded, small, dense; branches usually with 1–4 small, black, hard excrescences just above the leaf axils. Leaves alternate, paripinnately compound with (2–)3–4(–5) pairs of leaflets, glabrous; petiole 0.5–1 cm long, thick, rugose, jointed; rachis 4–20 cm long; petiolules c. 5 mm long, rugose; leaflets opposite, narrowly elliptical to oblong, (4.5–)10–30 cm × (1.5–)3–11 cm, leaflets larger to the top of the leaf, rounded to cuneate at the base, acute, obtuse or acuminate at the apex, leathery, glossy green above, paler beneath, venation reticulate, prominent, 5–10 pairs of lateral veins. Inflorescence an axillary or terminal panicle or spike-like raceme 4–16 cm long, densely hairy, accrescent, lignifying after flowering; bracts triangular, c. 1.5 mm long, persistent. Flowers bisexual, small, white, glabrous, fragrant; pedicel c. 1 mm long; sepals 5, largely connate, white, tube bell-shaped and c. 1.5 mm long, lobes rounded and c. 0.7 mm long; petals 5, narrowly obovate, c. 5 mm × 2 mm, apex rounded, tapering towards the base, recurved at anthesis, white; stamens 10, unequal, 5 long ones between the petals, c. 10 mm long, alternating with 5 shorter ones in front of the petals, c. 5 mm long; ovary superior, style c. 2 mm long. Fruit a slightly sickle-shaped pod up to 18 cm × 4.5 cm, flat, long-attenuate at the base, apiculate, woody, brown, smooth, 1–2-seeded. Seeds irregularly shaped, c. 3 cm × 1.5–2 cm, dark brown to black. Seedling with epigeal germination, glabrous; hypocotyl c. 1 cm long, epicotyl c. 12 cm long, with a few scales; cotyledons transversely oblong, c. 1 cm × 2 cm; first 2 leaves with 2 leaflets.

Stachyothyrsus comprises 2 or 3 species distributed in West and Central Africa.

Stachyothyrsus stapfiana grows rapidly. Trees in the understory and secondary forest usually have a poor stem form, angular, knotty and branched. The leaves of saplings and coppice shoots are much larger than those of normal trees, with leaflets up to 50 cm × 15 cm. In Liberia flowering is in March–April and fruiting in July–November, whereas in Côte d'Ivoire flowering is in July and fruiting in December–January. The plant regenerates commonly in moist places.

Ecology *Stachyothyrsus stapfiana* occurs in swampy locations in evergreen forest, moist semi-deciduous forest and secondary forest. It is common and locally dominant.

Management The tree coppices very well, and in Liberia a kind of coppice forest is locally maintained solely for the production of large leaves for thatching.

Genetic resources and breeding *Stachyothyrsus stapfiana* has a limited distribution area, but it is locally common and there are no indications that it is under threat of genetic erosion.

Prospects *Stachyothyrsus stapfiana* is a useful local source of thatching material, but its importance is unlikely to increase. The value of the wood is limited, because it is liable to termite attack, and the tree usually has a poor bole shape. As growth is fast and the tree coppices well, *Stachyothyrsus stapfiana* may have some potential as a source of fuelwood.

Major references Aubréville, 1959b; Burkill, 1995; Keay, Hoyle & Duvigneaud, 1958; Saville & Fox, 1967; Voorhoeve, 1979.

Other references Aubréville, 1970; Cooper & Record, 1931; Kryn & Fobes, 1959; Léonard & Voorhoeve, 1964; Normand, 1950; Normand & Paquis, 1976; Takahashi, 1978.

Authors M. Brink

STERCULIA AFRICANA (Lour.) Fiori

Protologue Agric. Colon. 5, suppl.: 37 (1912).

Family Sterculiaceae (APG: Malvaceae)

Chromosome number $2n = 36$

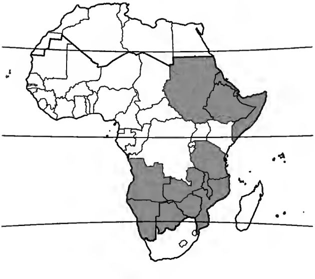
Synonyms *Triphaca africana* Lour. (1790), *Sterculia triphaca* R.Br. (1844), *Sterculia guerichii* K.Schum. (1894).

Vernacular names African star-chestnut, tick tree, false baobab (En). Mgoza, mdoza, ngoro (Sw).

Origin and geographic distribution *Sterculia africana* is distributed throughout East and southern Africa, except for Kenya and Uganda.

Uses The bark fibre is used for making mats, string and rope, and for tying in house construction. The wood is used for poles in house construction, for instance for making frameworks of movable houses of pastoralists, with the bark being used for tying the wood together. It is the preferred wood of the Damara people in Namibia for carving winnowing bowls. The wood is also used for making furniture, for fencing and as fuelwood. In Namibia the bark is burnt for its aroma. The tree produces a gum, which is used as additive to medicines, but the quantities are too small for commercial exploitation. The gum, which resembles gum tragacanth from *Astralagus* spp., was formerly used for making gun powder for muzzle-loading guns. In Malawi the fresh leaves are cooked in sauces with *Moringa* and/or okra. In Ethiopia the leaves are browsed by cattle, goats and sheep. The pods are used as amulets and snuff boxes. The ash of burnt fruits is used as a cooking soda, especially for cooking vegetables. Hairs from the fruit have been added to snuff to improve the flavour. The roasted seeds are eaten. In Malawi they are pounded into an oily paste before being eaten. The flour of roasted and pounded seeds is cooked and eaten with vegetables. Oil is extracted from roasted seeds. The dry seeds are used as beads. *Sterculia africana* is grown as a living fence and is a bee forage.

Sterculia africana is widely used in African traditional medicine. In Somalia a decoction of the crushed fresh roots is drunk as an anthelmintic. In Tanzania a root decoction is taken against back pain, hernia and dizziness, a root infusion is drunk as an aphrodisiac, and leaf decoctions are drunk against fungal infections and convulsions. In East Africa the roots, bark and leaves are boiled and the vapour inhaled for the treatment of influenza and fever. In Namibia a root or bark decoction is drunk by women for the treatment of postnatal and stomach pains, a leaf infusion is drunk against cough and chest complaints, and a fruit decoction is drunk to relieve pain during pregnancy and after giving birth. In Malawi the irritant hairs along the splitting point of the fruits are recorded to be burnt and the ash used as an ointment for the treatment of eye infections, especially in babies.



Sterculia africana – wild

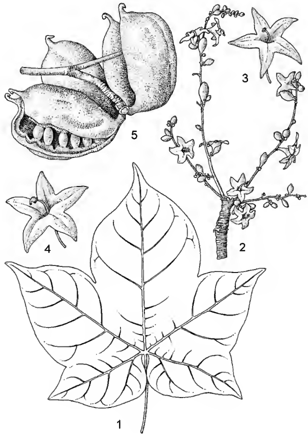
Properties The wood is pinkish or greyish, with the heartwood not distinctly demarcated from the sapwood. The wood is soft and very lightweight.

Dried leaves are more palatable for cattle and goats than green leaves. Dried foliage (dry matter content 88.7%) collected in Ethiopia in the wet season contained per 100 g dry matter: crude protein 12.7 g, hydrolysable tannins 14.2 g, neutral detergent fibre 35.7 g, acid detergent fibre 26.4 g and acid detergent lignin 6.9 g. The in-vitro dry matter digestibility was 78%. In the dry season the dried foliage (dry matter content 91.9%) contained per 100 g dry matter: crude protein 14.7 g, hydrolysable tannins 12.2 g, neutral detergent fibre 42.3 g, acid detergent fibre 21.1 g and acid detergent lignin 5.3 g, with an in-vitro dry matter digestibility of 84%. The in-sacco potential dry matter digestibility of the leaves was 93% in the wet season and 94% in the dry season, and the in-sacco potential nitrogen digestibility 90 and 91 g per kg dry matter for the wet and the dry season, respectively.

Methanol leaf extracts showed in-vitro antifungal activity against *Candida krusei*, *Candida parapsilosis*, *Candida tropicalis*, and *Cryptococcus neoformans*, but not against *Candida albicans* and *Candida glabrata*. In various assays these extracts also showed cytotoxic and genotoxic effects, and interaction potential with antiretroviral agents.

The fruits have irritating hairs. Seeds in Botswana contained per 100 g dry matter: crude protein 35.6 g, crude fat 22.8 g, tannins 3.5 g, neutral detergent fibre 15.4 g, acid detergent fibre 19.0 g, Ca 130 mg, Mg 250 mg and P 260 mg. The in-vitro true dry matter digestibility was 96%. Seeds in Botswana and Zimbabwe yielded about 32% oil, mainly composed of palmitic acid 17–20%, stearic acid 3–6%, oleic acid 17–21% and linoleic acid 26–27%. The oil contains up to 34% cyclopropenoid fatty acids known to cause physiological disorders in higher animals, and therefore it may not be recommended for food uses. The seed oil also contains β-sitosterol, stigmasterol, campesterol and γ-tocotrienol.

Description Deciduous, monoecious, small to medium-sized tree up to 12(–25) m tall; bole up to 250 cm in diameter; bark surface whitish grey or liver-coloured, peeling in papery flakes, inner bark green; crown rounded; branches spreading; young branches hairy. Leaves alternate, crowded at the ends of branches, simple; stipules early caducous; petiole up to 10(–12.5) cm long, with greyish stellate hairs; blade orbicular or ovate-cordate in outline, 3–5(–7)-lobed or entire, 3.5–15 cm × (3–)4–13 cm, lateral lobes separated by sinuses 0.5(–2) cm deep, the sinuses of the apical lobe being always deeper, base cordate, apex rounded to acuminate, both surfaces shortly and thinly stellate-hairy to glabrescent, c. 7-veined from the base. Inflorescence borne on leafless branch apices, 2–6(–20) per branch, spike-like or with 2–5 branches, up to 12 cm long, hairy. Flowers unisexual, regular, 5-merous, 7–8 mm long, up to 2.5 cm in diameter, greenish to yellowish with pink or red markings; pedicel up to 10 mm long, perianth campanulate with 5 lobes 7–9 mm × 4–4.5 mm, stellate hairy; male flowers with c. 10 anthers borne on a long common stalk; female flowers with superior ovary consisting of 5 loosely united carpels. Fruit consisting of 1–5 ellipsoid or oblong-ovoid follicles 4–15 cm long, each splitting down one side, beaked, tomentose to subscabrid, yellowish brown, suture fringed with irritating hairs 2–3 mm long, many-seeded. Seeds ellipsoid-oblong, 9–15 mm × 5–8 mm, grey-black, tick-like, with apical aril 2–3 mm × 3–5 mm, aril drying white.



Sterculia africana – 1, leaf; 2, flowering branch; 3, male flower; 4, female flower; 5, fruit.
Redrawn and adapted by Achmad Satiri Nurhaman

Other botanical information *Sterculia* comprises about 150 species and occurs throughout the tropics. In tropical Africa about 25 species can be found. The bark fibre of various *Sterculia* species is locally used like that of *Sterculia africana*.

Sterculia mhosya Engl. is a shrub or small tree up to 10 m tall, distributed in Tanzania and Zambia. Its bole is used for making canoes, its bark for making rope, its leaves as toilet paper and its seeds are eaten like groundnuts. A bark decoction is drunk against indigestion.

Sterculia rhynchocarpa K.Schum., a shrub or small tree up to 9(–15) m tall, distributed in Ethiopia, Somalia, Kenya and Tanzania, is very closely related to *Sterculia africana* and has been misidentified as *Sterculia africana* in Kenya. Its bark yields material for tying and its seeds are eaten. Leaf litter is eaten by goats and cattle. A decoction of the root and bark is drunk and used to wash the body for the treatment of malaria, and a bark decoction is drunk in case of stomach complaints. *Sterculia rhynchocarpa* is a host of the cotton pests *Dysdercus cardinalis* and *Dysdercus fasciatus*.

Sterculia rogersii N.E.Br. (common star-chestnut, small-leaved star-chestnut) is a shrub or small tree up to 8 m tall distributed in Botswana, Zimbabwe, Mozambique, Swaziland and South Africa. It yields a bark fibre of good quality used for tying in hut-building, for making fishing lines and nets, and as a thread for sewing sleeping mats and grain baskets. The seeds are eaten as a famine food, and livestock eats the seeds and aerial parts. The wood is soft and brittle, and the heartwood is recorded to have been eaten in times of famine.

Sterculia stenocarpa Winkler is a shrub or small tree up to 15 m tall, distributed in Sudan, Ethiopia, Somalia, Kenya, Uganda and Tanzania. Its bark is used for making tough and durable string and rope. Its twigs are used for cleaning milk containers in Kenya. Its fruit and seeds are edible. In traditional medicine in Kenya the root is boiled with butter in water and used for the treatment of indigestion in newborn babies and malaria in children. In Tanzania the leaves are pounded with water and squeezed, and the juice is applied on leprous sores, while the fresh bark enters in preparations taken for the treatment of abdominal pains accompanied by mild bleeding from the vagina.

Growth and development At 28 months after planting the average height of *Sterculia africana* planted at Chalimbana (Zambia) was 1.1 m, with an average stem diameter of 6.1 cm. Flowers generally appear before the new foliage. In southern Africa flowering is usually in September–December, and fruiting in January–June.

Ecology *Sterculia africana* occurs in hot, dry areas from sea-level up to 1800 m altitude in woodland, bushland or grassland, often on rocky slopes or outcrops.

Propagation and planting Seeds and cuttings can be used for propagation. The 1000-seed weight is 35–190 g. A germination rate of 65% after 20 days has been reported. Seeds retain viability for 2 months at room temperature.

Management *Sterculia africana* is mostly exploited from natural stands, but it is also planted and tended. The tree can be pruned and coppiced.

Diseases and pests *Sterculia africana* is a host of the cotton pests *Dysdercus cardinalis* and *Dysdercus fasciatus*.

Genetic resources In view of its wide distribution and range of habitats, *Sterculia africana* is not threatened with genetic erosion. In Namibia the species is protected by forestry legislation.

Prospects *Sterculia africana* is a useful multipurpose tree, not only yielding fibre for the local production of mats and ropes, but also a range of other products, including edible leaves and seeds. Oil extraction from its seeds has technically been demonstrated to be feasible and may have commercial potential. The seed oil is not safe for human consumption, but could be used for cosmetic purposes and biofuel. The irritating hairs on the fruit and the fact that it is host of cotton stainers may limit the potential of *Sterculia africana*.

Major references Bekele-Tesemma, 2007; Cheek & Dorr, 2007; Coates Palgrave, 1983; Hamza et al., 2006; Melaku, Aregawi & Nigatu, 2010; Mitei et al., 2009; Palmer & Pitman, 1972–1974; SEPASAL, 2010f; Thulin, 1999b; van den Bout van den Beukel et al., 2008.

Other references Aganga et al., 2000; Aregawi, Melaku & Nigatu, 2008; Beentje, 1994b; Bein et al., 1996; Booth & Wickens, 1988; Chikuni, 1994; Cornelius et al., 1970; Dharani, 2002; Hedberg et al., 1983; Ichikawa, 1987; Kamara & Maghembe, 1994; Mbuya et al., 1994; Mitei et al., 2008; Neuwinger, 2000; Pratt et al., 2002; Ruffo, Birnie & Tengnäs, 2002; Schmidt, Lötter & McCleland, 2002; van den Eynden, Vernemmen & van Damme, 1992; van Wyk & van Wyk, 1997; Williamson, 1955.

Sources of illustration Thulin, 1999b.

Authors F.W. Owusu & N.S.A. Derkyi

STRYCHNOS BOONEI De Wild.

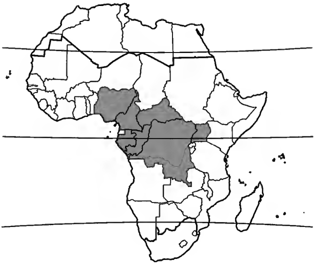
Protologue Bull. Jard. Bot. Etat 5: 45 (1915).

Family Loganiaceae

Origin and geographic distribution *Strychnos boonei* is distributed from Nigeria eastward through northern Central Africa to Uganda.

Uses In Congo the stems are used for reinforcing the sides of baskets.

Properties The wood is pale yellow. The root bark and stem bark contain alkaloids. Stem bark extracts showed muscle-relaxant



Strychnos boonei – wild

effects and tonic convulsion. The leaf is not bitter when chewed.

Botany Large liana up to 100 m long, unarmed; stem 3–10 cm in diameter, sometimes more; bark smooth, pale brown, often inconspicuously lenticellate; branches pale grey-brown, not lenticellate, young branchlets brown-puberulous; tendrils solitary, in the axils of small bracts. Leaves decussate, simple and entire; stipules absent; petiole 2–7 mm long, sparsely hairy; blade elliptical, ovate or narrowly obovate, 2.5–10 cm × 1–4.5 cm, base cuneate, rounded or sometimes subcordate, apex acuminate, papery to thinly leathery, glabrous above, sparsely brown-hairy at base below, medium to dark green above, paler below, 3-veined from the base. Inflorescence an axillary or terminal cyme, 1.5–3 cm long, lax, spreading, branched, thinly brown-hairy, few-flowered; bracts triangular to ovate, small. Flowers bisexual, regular, 5-merous, sweet-scented, bracteolate; sepals fused at base, broadly ovate to triangular, 1–1.5 mm long; corolla tube 1–2 mm long, glabrous, lobes oblong, 2.5–3 mm long, acute, recurved, white or creamy, densely hairy within; stamens inserted at the mouth of the corolla tube, exserted; ovary superior, globose to ovoid, c. 1 mm long, 2-celled, style c. 2.5 mm long, stigma capitate. Fruit an ellipsoid to subglobose berry c. 2.5 cm in diameter, soft, dark purple, 1-seeded. Seeds ellipsoid, slightly flattened, c. 14 mm × 7–11 mm × 4–9 mm.
Strychnos comprises about 200 species: about 60 species in Asia, 65 in America and 75 in Africa.

Ecology *Strychnos boonei* occurs from sea-level up to 1300 m altitude in rainforest, semi-deciduous forest and secondary forest, often along watercourses.

Genetic resources and breeding In view of its wide distribution *Strychnos boonei* seems not threatened with genetic erosion.

Prospects *Strychnos boonei* will remain of occasional local use only.

Major references Bruce & Lewis, 1960; Burkill, 1995; Leeuwenberg, 1969; Leeuwenberg, 1972.

Other references Leeuwenberg & Bamps, 1979; Ohiri, Verpoorte & Baerheim Svendsen, 1983; Onochie & Leeuwenberg, 1963.

Authors M. Brink

THALIA GENICULATA L.

Protologue Sp.pl. 2: 1193 (1753).

Family Marantaceae

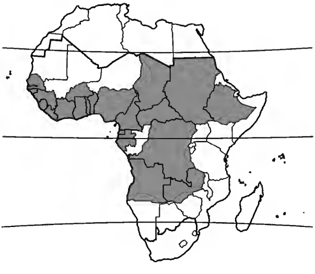
Chromosome number $2n = 18, 26$

Synonyms *Thalia welwitschii* Ridl. (1887).

Vernacular names Alligator flag, bent alligator flag, fire flag (En).

Origin and geographic distribution *Thalia geniculata* originates from America, where it occurs in the south-eastern United States, Mexico, Central America, the Caribbean and South America. Because of the lack of variation among the African populations, it is believed to have been introduced into tropical Africa, where it has widely naturalized and it is now distributed from Senegal eastward to Sudan and Ethiopia and southward to Angola and Zambia. *Thalia geniculata* has the widest distribution of all *Marantaceae*.

Uses The leaves are widely used for thatching and packing. In Ghana they are also used for covering walls. The leaves are often used for wrapping food products, such as kola nuts and maize products, and to line food containers. In Gabon the rolled leaves are used as plugs for bottles and calabashes. In Sierra Leone the leaves are used as a bandage for circumcision wounds. The stems are used in basketry, for fencing and for making fish-traps, furniture, ladders and bridges. In Ghana they form the framework of walls to be daubed with mud. The split stems are plaited into mats.
The leaves are sometimes eaten in Burkina Faso. In Ghana *Thalia geniculata* is given as fodder to small ruminants. Ash from the burnt stem has been used for making salt. The plant is valued as a garden pond plant, especially the



Thalia geniculata – naturalized

types with red petioles.

In traditional medicine in Senegal the roots and leaves are parts of preparations drunk and massaged in case of snakebite. In Côte d'Ivoire a maceration of the root is drunk and used in baths for the treatment of anaemia. In Ghana a root infusion is drunk for the treatment of asthma. In Benin unspecified plant parts are used for the treatment of malaria.

Production and international trade Information on production and international trade is not available. The leaves are often traded in local markets, e.g. in Benin.

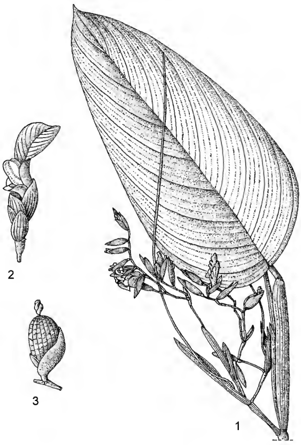
Properties The leaves give a specific aroma to the food wrapped in them. Investigations in Ghana have shown that *Thalia geniculata* stems are suitable as reinforcing bars in concrete.

A methanolic extract of the root has shown antiplasmodial activity against both chloroquine-sensitive and chloroquine-resistant *Plasmodium falciparum* strains. The aerial parts were found to contain sitoindoside I, daucosterol, stigmasterol, β-sitosterol and geranylfarnesol. Geranylfarnesol, isolated from the aerial parts of the plant, showed significant antiprotozoal activity against *Plasmodium falciparum* and *Leishmania donovani*. The leaves contain rosmarinic acid.

Experiments in the United States have shown that wetland systems with *Thalia geniculata* have potential for recovering N and P from wastewater.

Adulterations and substitutes The leaves and stems of various other *Marantaceae* are used for similar purposes.

Description Perennial, straggling herb up to 3.5 m tall, with short rhizome, tufts of leaves, and stems bearing an inflorescence and a single subtending leaf or sheath. Leaves imbricate; petiole sheathing at the base, basal sheath 20–40 cm long, uncalloused part of petiole 20–40 cm long, apical calloused part up to 2.5(–4) cm long, transition of the petiole into the midvein marked above by a depression at right angles to the midvein, green or occasionally red-purple, glabrous; blade subtriangular to ovate, rarely elliptical, oblong or sublinear, (12–)19–63 cm × (2–)4–26 cm, base rounded to subcordate, apex acute to acuminate, glabrous. Inflorescence a lax panicle up to 40 cm long; axis zig-zag, much branched, internodes 0.5–2 cm long; abaxial bracts 1–3.5 cm long, green or purplish, caducous, supporting a single cymule; cymule 2-flowered, backed by an adaxial bract, common peduncle absent. Flowers bisexual, zygomorphic, purple, sessile or on pedicel up to 2 mm long; bracteole absent, sepals 3, free, equal, ovate to elliptical, 0.5–2 mm long; corolla 6–13 mm long, with short tube and 3 lobes; staminodes and stamen in 2 cycles, at the base forming a tube fused to the corolla tube, outer cycle consisting of 1 petaloid staminode with clawed base, inner cycle consisting of 1 stamen and 2 staminodes, of which 1 hooded with 2 linear appendages; ovary inferior, 1-locular, style helically twisted, stigma appendaged. Fruit an ellipsoid to subglobose capsule up to 12 mm × 7 mm, indehiscent, orange-red, reticulate when dry, with persistent calyx, with membranous pericarp, 1-seeded. Seed ellipsoid to subglobose, 5–10 mm × 3–6 mm, smooth, brownish to greyish or black, with conspicuous to rudimentary aril.



Thalia geniculata – 1, leaf with inflorescence; 2, flower; 3, fruit.
Redrawn and adapted by Achmad Satiri Nurhaman

Other botanical information *Thalia* comprises about 7 species, distributed in tropical America, with 1 species also in tropical Africa. Typical for the genus are the hooded staminode with 2 appendages and the appendaged stigma. Also characteristic is the presence of air chambers in the leaf sheath, giving the sheath its distinctive spongy texture and providing adaptation to aquatic habitats.

Growth and development Pollination is triggered by bees and hummingbirds, but self-pollination is also possible. Natural reproduction is by seed and via rhizomes. The seeds and rhizome pieces are dispersed by water. A gas-filled space between the seed and the fruit wall makes the fruit buoyant.

Ecology *Thalia geniculata* occurs in swamps, near pools and in other wet locations in forest, savanna and fallow land, from sea-level up to 1100 m altitude. It occurs as a weed, particularly in rice cultivation. It does not tolerate frost or salt water.

Propagation and planting *Thalia geniculata* can be propagated by rhizome division or with seed. The 1000-seed weight is 50–80 g.

Management *Thalia geniculata* can be grown in moist soil or water up to 25 cm deep.

Handling after harvest Before being used to wrap 'lio' (a fermented maize product) in Benin, the leaves are soaked in boiling water, after which they have a brown colour and are softer.

Genetic resources In view of its extremely wide distribution *Thalia geniculata* is not threatened with genetic erosion.

Prospects The leaves and stems of *Thalia geniculata* are widely used for thatching, packing and plaiting. The species seems not overexploited, but the plant may have potential for cultivation for local use, and research on propagation and management practices may be worthwhile. The antiplasmodial properties may warrant further investigation.

Major references Abbiw, 1990; Akoègninou, van der Burg & van der Maesen, 2006; Andersson, 1981; Burkill, 1997; Claβen-Bockhoff, 1991; Davis, 1987; Koechlin, 1965; Lagnika et al., 2008; Lye & Friis, 1997; Weniger et al., 2004.

Other references Abdullah, Schneider & Petersen, 2008; Acevedo-Rodríguez & Strong (Editors), 2005; Adams, 1972; d'Oliveira Feijão, 1961; Hepper, 1968c; Hermans, Akoègninou & van der Maesen, 2004; Kankam & Odum-Ewuakye, 2006; Kennedy, undated; Kerharo & Adam, 1974; Koné & Kamanzi, 2006; León, 1946; Nana, Brouwer & Traoré, 2003; Nash & Stroupe, 2003; Neuwinger, 2000; Odoi et al., 2002; Polomski et al., 2008; Raponda-Walker & Sillans, 1961; Speichert & Speichert, 2008; Thomas, 1959; Wagner, 2004.

Sources of illustration Hepper, 1968c; Koechlin, 1964.

Authors N.S. Alvarez Cruz

TILIACORA FUNIFERA (Miers) Oliv.

Protologue Fl. Trop. Afr. 1: 44 (1868).

Family Menispermaceae

Synonyms *Tiliacora warneckei* Engl. ex Diels (1910), *Tiliacora johannis* Exell (1935).

Vernacular names Elbow-leaf, stem-fruit climber (En).

Origin and geographic distribution *Tiliacora funifera* is widely distributed in tropical Africa, from Ghana eastward to Ethiopia and Somalia and southward to Angola, Zimbabwe, Mozambique and South Africa.

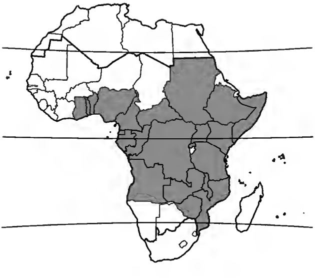
Uses The stem without the bark is used as a coarse binding material, for instance for tying roofs and bundles of firewood. In DR Congo the fruit is eaten.

In Ghana plant preparations are drunk for the treatment of gastric fever, hernia and menstrual problems. In Congo sap from the leaves forms part of preparations against insanity. In South Africa an extract of the root mixed with other plant ingredients is taken by women to increase fertility. To treat problems of the face, leaves are boiled and applied to the face as a steam bath.

Production and international trade The root is commonly traded as a medicine, for instance in Maputo (Mozambique).

Properties The central part of the stem is flexible and tough like a rattan.

Both leaf and rhizome extracts showed moderate anticancer activity (total growth inhibition <10 μg/ml) against MCF7 (breast cancer), UACC62 (melanoma) and TK10 (renal cancer)



Tiliacora funifera – wild

cell lines. This activity is supported by the presence of the alkaloid isotetrandrine known for its antitumour activity. Root and stem extracts showed antiplasmodial activity against *Plasmodium falciparum*. The extracts contained the bisbenzylisoquinoline alkaloids (+)-funiferine-2'-N-oxide, (+)-funighanine and (+)-2'-norfunighanine. The toxicity of the extract was relatively low.

The roots and leaves contain bisbenzylisoquinoline alkaloids, including funiferine dimethiodide. The roots also contain tiliacorine, funiferine, isotiliarine and pseudotiliarine, and the quaternary benzylisoquinoline monomer oblongine. Many (bis)benzyl-tetrahydro-isoquinoline alkaloids have been isolated from *Tiliacora funifera* extracts.

Botany Robust, dioecious, woody liana up to 20 m long. Leaves alternate, simple and entire; stipules absent; petiole slender, 1.5–5 cm long, with swelling or slight articulation before joining the leaf blade at an angle, hairy to glabrescent; blade ovate-lanceolate, ovate-oblong or broadly ovate, 5–20 cm × 3–10 cm, subcordate to rounded or somewhat obtuse at base, obtuse to acute or acuminate at apex, papery or leathery, usually glabrous, sometimes sparsely hairy beneath. Male and female inflorescences similar, either an axillary solitary cymule on a c. 1 cm long peduncle, or a 3–9-flowered cymule, solitary or clustered in a false raceme which is axillary or springing from old stems, up to 15 cm long; axes and peduncles hairy. Flowers unisexual; male flowers with 6–9 sepals, the 3–6 outer ones triangular to orbicular, 1–1.5 mm × 1–1.5 mm, thickened and ciliolate, the 3 inner ones obovate-elliptical, 3.5–4 mm × 2–2.5 mm, petals 6, 1.5–2.5 mm long, clawed, thickened on margins, stamens exserted, 3–5 mm long, free or slightly united at base; female flowers with 6–9 sepals, the outer ones lanceolate to ovate, 1–2 mm long, the inner ones suborbicular, c. 2.5 mm × 2.5 mm, petals (5–)6, 1–1.5 mm long, staminodes absent, ovary of 8–12 carpels, about 1 mm long. Fruit composed of obovoid to nearly round drupelets, 5–7 mm long, orange or yellow; stipe 1.5–3 mm long; exocarp glabrescent, smooth or verrucose; endocarp compressed, woody, furrowed.

In Ghana *Tiliacora funifera* flowers in June, in Zimbabwe and Mozambique from August to October.

Tiliacora comprises about 20 species of which 3 occur in tropical Asia and 17 in Africa; it is in need of a taxonomic revision. The variation within *Tiliacora funifera* is large.

Ecology *Tiliacora funifera* occurs from sea-level up to 2000 m altitude in lowland and upland rain-forest, riverine and other evergreen forest, and moist, shady places in woodland, thickets and grassland.

Management *Tiliacora funifera* is only collected from the wild.

Genetic resources and breeding Because of its large area of distribution, *Tiliacora funifera* is not in danger of genetic erosion.

Prospects The importance of *Tiliacora funifera* as a fibre plant is unlikely to increase. Although several of its chemical constituents have interesting pharmacological properties, they have not become important in the production of medicines. Recently discovered anticancer properties, ascribed to isotetrandrine, are not unique to this species.

Major references Burkill, 1997; de Wet, Fouche & van Heerden, 2009; Tackie et al., 1980; Tackie & Thomas, 1968; Troupin, 1960.

Other references Ayim et al., 1977; Barbosa-Filho, Da-Cunha & Gray, 2000; Böhlke, 1997; Dwuma Badu et al., 1977; Dwuma Badu et al., 1978; Krog, Falcão & Smith Olsen, 2006; Malaisse, 1997; Neuwinger, 2000; Owusu-Dapaah, 1993; Schmidt, Lötter & McCleland, 2002.

Authors L.P.A. Oyen

TILIACORA LOUISII Troupin

Protologue Bull. Jard. Bot. Etat 19: 412 (1949).

Family Menispermaceae

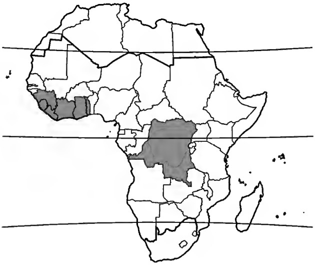
Synonyms *Tiliacora polygyna* Diels ex Mildbr. (1937).

Origin and geographic distribution *Tiliacora louisii* is recorded from Guinea and Sierra Leone eastward to Togo, and in DR Congo.

Uses In Sierra Leone the stems are used for tying house posts.

Production and international trade *Tiliacora louisii* is of local importance only.

Botany Woody liana with twining stem of several meters long and up to 1.5 cm in diameter, slightly grooved. Leaves alternate, simple; petiole thin, c. 1 cm long, glabrous; blade oblong-lanceolate, 6–13 cm × 2–5.5 cm, base rounded or acute, apex with acumen up to 2 cm long, glabrous, somewhat leathery, secondary veins in 6–8 pairs at nearly right angles to the midrib. Male inflorescence a false raceme of 1-flowered cymules 4–7 cm long, on leafless branches, bracteole 2–3 mm long, cymules on a



Tiliacora louisii – wild

peduncle 2–4 mm long; female inflorescence unknown. Flowers unisexual; male flower petiolate, sepals 9, 3 outer ones triangular, 1 mm long, thickened in the middle, 3 middle ones ovate, c. 1.5 mm long, 3 inner ones oblong-elliptical, boat-shaped, 8–10 mm × 4–5 mm, green with violet, petals 6, oblong, 1.5 mm × 1 mm, apex rounded, stamens 6, filaments 6–8 mm long, slightly connate at base, anthers c 1.5 mm long; female flower unknown. Fruit an obovoid drupe c. 15 mm × 5–7 mm, smooth, orange-red when mature; pulp fleshy, 3 mm thick; endocarp thin. Seeds 8–10 mm long.

Tiliacora comprises about 20 species of which 3 occur in tropical Asia and 17 in Africa; it is in need of a taxonomic revision.

Ecology *Tiliacora louisii* occurs in lowland forest, often in swampy conditions.

Management Stems of *Tiliacora louisii* are only collected from the wild.

Genetic resources and breeding Information on *Tiliacora louisii* is inadequate to assess its genetic vulnerability.

Prospects *Tiliacora louisii* is likely to remain of occasional local use only.

Major references Burkill, 1997; Keay & Troupin, 1954; Troupin, 1951.

Other references Jacques, 2009; Troupin, 1949.

Authors L.P.A. Oyen

TRACHYPHRYNIUM BRAUNIANUM (K.Schum.) Baker

Protologue Oliv., Fl. trop. Afr. 7: 319 (1898).

Family Marantaceae

Chromosome number $2n = 22$.

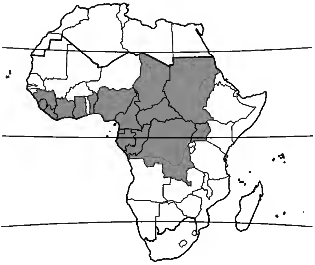
Synonyms *Hybophrynium braunianum* K.Schum. (1892).

Origin and geographic distribution *Trachyphrynium braunianum* is distributed from Guinea and Sierra Leone eastward to Sudan and Uganda and southward to Cabinda (Angola).

Uses The stems are widely used for tying and for plaiting mats, baskets, strainers, beehives and traps for fish and rats. In Ghana the stem and leaves are used for thatching huts for temporary use. In DR Congo the stems are used as rafters before the thatch is placed. In Gabon they form part of the main frame of huts and are used as support for daubed clay in walls. In Nigeria the stems are used as stakes in yam cropping. The leaves are widely used for wrapping food products.

The fruit is eaten in DR Congo. The Baka people in Cameroon consume the roasted seeds as a snack. In Ghana the aril is eaten and the seeds are used for making beads and necklaces. The flowers yield bee forage.

In Ghana young shoots are chewed with kola nuts as an aphrodisiac. In Nigeria the root and fruit are used as ingredients of mixtures to promote the growth of the foetus, and the aril is taken for the treatment of cough. In Congo a decoction of the twigs is drunk against hernia and stomach-ache, and the heated and pulped leaves are used as a poultice for dried and



Trachyphrynium braunianum – wild

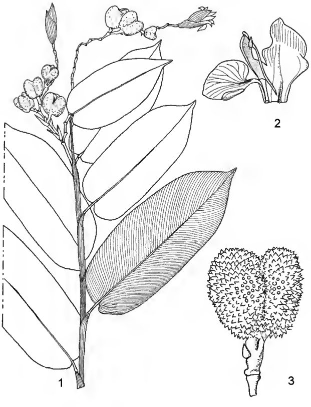
cracked soles of the feet. Sap from the root, often mixed with that of other *Marantaceae*, is given for the treatment of insanity, and a mixture of the roasted and pulverized root with salt and seeds of *Aframomum melegueta* K.Schum. is rubbed into scarifications for the treatment of rheumatism. In DR Congo a poultice of the leaves is applied as an anti-inflammatory.

Production and international trade In 2006 bunches of leaves to be used for food wrapping were sold at a price of US$ 0.22 in the markets of Kisangani and Mbandaka (DR Congo).

Properties Tests for the presence of alkaloids, flavonoids, saponins, quinones, tannins and terpenes all gave negative results.

Adulterations and substitutes A good substitute of *Trachyphrynium braunianum* is *Hypselodelphys violacea* (Ridl.) Milne-Redh. (synonym: *Trachyphrynium violaceum* Ridl.), which has similar uses, particularly for basket making and in construction. Rattans are also used similarly.

Description Perennial, woody herb with bamboo-like shoots up to 4.5(–10) m tall, forming thickets; rhizome creeping, much branched; stems erect or supported by other plants, below simple and clothed with sheathing cataphylls up to 21 cm long, above branched and leafy. Leaves distichous; petiole sheathing below, jointed shortly above the top of the sheath, above the joint 0.5–1.5 cm long and calloused, joining the base of the midvein without interruption; blade oblong-elliptical, slightly asymmetrical, with the more curved margin nearer to the stem, very variable in size, 5.5–20 cm × 2–10 cm, base rounded or cordate, apex shortly acuminate, glabrous, with numerous parallel lateral veins at c. 45° from the midvein. Inflorescence terminal, spike-like, up to 20 cm long, simple or sometimes branched at the base, with at every node an abaxial, caducous bract 15–25 mm long enveloping a cymule; cymules 2-flowered, with an adaxial bract; peduncle of cymule 2–4 mm long. Flowers bisexual, zygomorphic, 2–2.5 cm long, white, sometimes tinged pink or purple; bracteole 1, fleshy, c. 2 mm long; sepals free, equal; corolla tubular below, with 3 lobes; staminodes and stamen in 2 cycles, at the base forming a tube fused to the corolla tube, outer cycle consisting of 2 petaloid staminodes, inner cycle consisting of 1 stamen and 2 staminodes, of which 1 hooded with a spur-like appendage; ovary inferior, papillose, 3-locular. Fruit a dehiscent capsule c. 1.5 cm × 1.5 cm, muricate, orange-yellow, 1–3-seeded, lobed if more than 1-seeded, obovoid or lobes obovoid. Seeds ellipsoid or obovoid, c. 7 mm in diameter, smooth, glossy black or brownish, with a basal, brownish white aril.



Trachyphrynium braunianum – 1, part of flowering stem; 2, part of flower; 3, fruit.
Source: Flore analytique du Bénin

Other botanical information The genus *Trachyphrynium* is monotypic. Several related species were previously classified in *Trachyphrynium*, but these are now reclassified into *Haumania* or *Hypselodelphys*. Recent phylogenetic studies indicated much similarity between *Trachyphrynium* and *Hypselodelphys*.

Growth and development In Benin flowering is in August, and fruiting in August–December.

Ecology *Trachyphrynium braunianum* occurs from sea level up to 1200 m altitude in wet locations in rainforest, gallery forest, secondary forest and cleared land.

Propagation and planting *Trachyphrynium braunianum* reproduces naturally by seeds or suckers.

Management In south-eastern Ghana the presence of *Trachyphrynium braunianum* is associated with high soil fertility, and during land clearance the plant is usually preserved as it is considered to be beneficial for soil fertility.

Harvesting Leaves and stems are carefully cut with a knife or cutlass without killing the plant.

Genetic resources *Trachyphrynium braunianum* is generally abundantly available in its distribution area. In Togo, however, the plant is classified as rare.

Prospects In spite of its local importance for rural communities, *Trachyphrynium braunianum* has rarely been studied, and therefore very little information is available on this plant, especially with respect to properties and management.

Major references Andersson & Chase, 2001; Burkill, 1997; Dhetchuvi, 1996a; Hepper, 1968c; Koechlin, 1965; Milne-Redhead, 1952; Prince & Kress, 2006a; Prince & Kress, 2006b; Raponda-Walker & Sillans, 1961.

Other references Akoègninou, van der Burg & van der Maesen, 2006; Amanor, 1991; Anonymous, 2003; Bouquet & Debray, 1974; Brisson, 1988; Cabezas et al., 2005; Dhetchuvi, 1993; d'Oliveira Feijão, 1961; Hattori, 2006; Kawukpa & Angoyo, 1994; Koni Muluwa & Bostoen, 2008b; Ku Mbuta et al., 2008; Liengola, 2001; Lubini, 1994; Milne-Redhead, 1950; Neuwinger, 2000; Thornell, 2005; Toirambe Bamoninga, 2007; White & Abernethy, 1997; Zapfack et al., 2001.

Sources of illustration Akoègninou, van der Burg & van der Maesen, 2006.

Authors V.A. Kémeuzé

TRACHYPOGON SPICATUS (L.f.) Kuntze

Protologue Revis. gen. pl. 2: 794 (1891).

Family Poaceae (Gramineae)

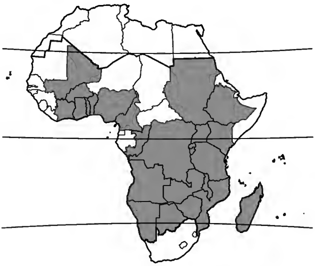
Chromosome number $2n = 20$

Synonyms *Trachypogon plumosus* (Humb. & Bonpl. ex Willd.) Nees (1829).

Vernacular names Giant spear grass, greybeard grass, spiked crinkleawn, arrow grass (En).

Origin and geographic distribution *Trachypogon spicatus* is widely distributed in tropical Africa, from Côte d'Ivoire eastward to Ethiopia and southward to South Africa and Madagascar. It also occurs in the Americas, from the southern United States southward to Paraguay.

Uses *Trachypogon spicatus* is used as thatch on houses. It has some suitability for pulping. It is only grazed when it is very young. It tends to form a dense soil cover providing protection against erosion in areas with high rainfall. It is considered a weed of plantations in Tanzania, but it is easy to control.


Trachypogon spicatus – wild

Production and international trade *Trachypogon spicatus* is only used locally.

Properties The palatability of *Trachypogon spicatus* is low, except when the foliage is very young. Chemical analysis of fresh material in the early flowering stage in Kenya recorded: crude protein 5.7%, crude fibre 40.2%, ash 9.6%, ether extract 1.8% and nitrogen-free extract 42.7% on a dry matter basis. The root secretes a substance which stimulates germination of the seed of *Tagetes minuta* L.

Botany Perennial, tufted grass; stems up to 200 cm tall, bearded at the nodes. Leaves alternate; sheath with auricles at the mouth; ligule membranous, without a hairy fringe; blade filiform to linear, 15–40 cm × 1–7 mm, flat or with margins rolled in. Inflorescence terminal, composed of 1(–5) racemes 4–30 cm long; rachis tough, with linear internodes, glabrous. Spikelets paired, 1 subsessile, 1 pedicelled; subsessile spikelet male or sterile, oblong, 8–13 mm long, dorsally compressed, awnless, narrowly and usually inconspicuously winged on the margins above, persistent on the rachis; pedicelled spikelet 2-flowered, subterete, 8–13 mm long including the white bearded callus 1–3 mm long, pungent, obliquely attached to the internode, lower glume oblong, as long as spikelet, obtuse at the apex, leathery, glabrous or hairy, lower floret sterile, reduced to a hyaline lemma, upper floret bisexual, lemma linear, 0.5 mm long, entire, with a flexuous, pubescent or plumose awn 4–10 cm long, palea absent or minute, lodicules 2, stamens 3, ovary glabrous, stigmas 2. Fruit a rounded caryopsis (grain).

In southern Africa *Trachypogon spicatus* grows mainly during summer and late summer. Its growth rate is moderate to slow. Flowering in southern Africa is in October–May. The awn twists under the influence of moisture which may aid in burying the seed into the soil. *Trachypogon spicatus* uses the C_4 photosynthetic pathway.

Trachypogon is classified in the *Andropogoneae*. It comprises 3–5 species and is distributed in tropical Africa (including Madagascar) and tropical America. The genus is unusual in that the sessile spikelet is male or sterile and awnless.

Ecology *Trachypogon spicatus* generally occurs in wooded grassland and bushland, sometimes favouring the margins of flood plains and drainage tracts, from sea-level up to 2800 m altitude in equatorial areas and from sea-level up to 1700 m in southern tropical Africa. In South Africa *Trachypogon spicatus* occurs in the wet, subtropical eastern mountain and Highveld region as well as along the southern to south-western parts at 500–2300 m altitude. Rainfall may be from 600–1500 mm per year. It is a climax species that increases in lightly utilized rangeland. It usually occurs on sandy and gravelly soils, but may also be found near seasonal wetlands. In the Highland Sourveld in South Africa *Trachypogon spicatus* is characteristic of patches left ungrazed by cattle. In the ungrazed patches, soil moisture and soil depth were higher and the nutrients K and P were lower than in grazed patches, while more palatable grasses dominated in the grazed patches. Regular controlled burning and light grazing increase the proportion of *Trachypogon spicatus* in the vegetation, as it also increases more palatable species such as *Themeda triandra* Forssk. In Madagascar it is very common in slightly degraded pasture in Plateau areas. *Trachypogon spicatus* has shown tolerance of soil copper in spoils of copper mining in Zambia. High levels of copper are accumulated in the roots.

Management *Trachypogon spicatus* is not cultivated.

Genetic resources and breeding *Trachypogon spicatus* is widespread and common; it is not in danger of genetic erosion.

Prospects *Trachypogon spicatus* is likely to remain a thatch grass and forage grass of limited value. It may gain importance in erosion control, where its limited palatability is an advantage.

Major references Clayton & Renvoize, 1982; Cope, 2002; Dougall & Bogdan, 1958; Hoare, undated; Skerman & Riveros, 1990.

Other references Bogdan, 1977; Drew & Reilly, 1972; Dujardin, 1978; ECOCROP, 2007e; Everson & Tainton, 1984; Lütge, Hardy & Hatch, 1998; Phillips, 1995; Silberbauer-Gottsberger, 1984; van Oudtshoorn, 1999; Watt & Breyer-Brandwijk, 1962.

Authors L.P.A. Oyen

TRIPHYOPHYLLUM PELTATUM (Hutch. & Dalziel) Airy Shaw

Protologue Kew Bull. 1951: 342 (1952).

Family Dioncophyllaceae

Chromosome number $2n = 24, 36$

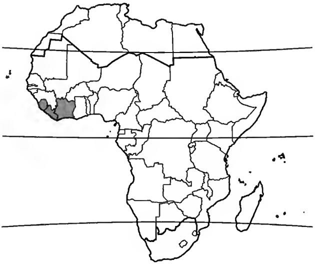
Synonyms *Dioncophyllum peltatum* Hutch. & Dalziel (1927).

Origin and geographic distribution *Triphyophyllum peltatum* occurs in Sierra Leone, Liberia and the bordering area of Côte d'Ivoire. A single collection from Gabon needs confirmation.

Uses The stems are used as tying material, for instance for tying house-posts and rafters. To get a refreshing drink, the stem is cut and the sap flowing from it is drunk. The root is purgative and very poisonous in higher doses. The pounded leaves and inner bark are applied topically to treat elephantiasis and are made into poultices against abdominal pain.

Production and international trade The stems are only used locally.

Properties A number of naphthoquinones, tetralones and naphthylisoquinoline alkaloids have been identified in extracts of *Triphyophyl-*



Triphyophyllum peltatum – wild

lum peltatum. Like other *Dioncophyllaceae* and the related *Ancistrocladaceae*, *Triphyophyllum peltatum* is typical for its naphthylisoquinoline alkaloid constituents, all formed via a unique pathway from acetate units. Prominent among the isoquinolines identified are dioncophylline A, dioncopeltine A and dioncolactone A. Others include dioncophylline B, dioncophyllacine B, dioncophylline C, dioncophylline D, 8-O-dioncophylline D and dioncophyllinol D. The 3 dioncophyllines are stereoisomers, but have different biological properties; dioncophylline A has shown good molluscicidal activity against *Biomphalaria glabrata*, the intermediate host of bilharzia, dioncophylline B has antifungal properties against some plant-pathogenic fungi, dioncophylline C (like dioncopeltine A) is a promising lead against both the blood- and the liver-form of *Plasmodium falciparum* and *Plasmodium berghei*. Jozomine A, a synthetic dimer of dioncophylline A, is even about 20 times more active. The synthetic dimer of dioncophylline C, named jozomine C, has little activity against malaria parasites, but is a promising lead against HIV-1, with $LC_{50} = 27$ µg/ml. Other compounds identified include the more common isoshinanolone, plumbagin and droserone, which are formed when the isoquinoline metabolism is interrupted by stress. The bark of *Triphyophyllum peltatum* contains the common lupane-type triterpene betulinic acid, which has some antimalarial properties. From solid callus cultures of the shoot of *Triphyophyllum peltatum* the quinones dioncoquinone A and dioncoquinone B and droserone have been isolated. Both dioncoquinone A and dioncoquinone B showed antiprotozoal activity against *Leishmania major* and antitumour activity.

Botany Scandent shrub or liana up to 20 m long, seasonally carnivorous; scandent branches terete, thin, glabrous, bearing short, leafy axillary branches. Leaves alternate, entire, of 3 forms: the first form on long shoots, blade narrowly oblong-elliptical, 6–16 cm × 1.5–3 cm, base cuneate, apex obtuse, midrib extending into a prominent forked acumen with recoiled arms; the second form on short shoots, blade oblong-lanceolate, 20–35 cm × 1–5 cm, without apical coils; the third form on young coppice shoots, blade partially or all reduced to the midrib and bearing many stipitate, viscid glands; petiole c. 1 cm long, articulate in the middle, leaving a persistent peg on the stem after falling; blade leathery, glabrous, midrib more prominent above than below, venation inconspicuous. Inflorescence a cyme, in the axils of short branches, minutely rusty velvety, few-flowered; bracts c. 2 mm long. Flowers bisexual, actinomorphic; pedicel up to 3 cm long; sepals 5, triangular, c. 2 mm long, persistent; petals 5, obovate, c. 13 mm long, thick and somewhat leathery; stamens 10, very short, anthers oblong; ovary superior, obovoid, opening early with (4–)5 valves, styles 5, small, elliptical-lanceolate, ending in numerous, narrow lobes, spreading. Fruit a capsule up to 4 cm in diameter when mature; valves elliptical-lanceolate, 1.5–3 cm × c. 7 mm, sharp apiculate, usually 1-seeded; funicles up to 5.5 cm long, extending far outside the fruit under an acute angle. Seeds hanging from the open valves of the fruit, developing in the open, discoid, 4.5–7 cm in diameter including the surrounding wing; body semi-spherical, 1–1.5 cm in diameter; wing membranous, c. 2 cm in diameter, bright red or pinkish, edge wavy, crenulate, thin-papery.

Triphyophyllum peltatum is heterophyllous, bearing leaves of 3 types, 2 on non-climbing, short shoots, and the third on the mature lianous stem. The short shoots produce mostly normal, eglandular, lanceolate leaves, but just before the height of the rainy season small clusters of relatively short-lived, glandular leaves with a strongly reduced blade or without a blade are formed. These glandular leaves bear both stalked and sessile glands, and efficiently trap insects and other small animals. The stalked glands, of which there are two size classes, are anatomically very elaborate and contain vascular elements. Structurally there are similarities with the stalked glands of *Drosophyllum* and *Drosera*. At maturity they carry secretion droplets, and stimulation by a prey leads to further secretion. The secretions contain a range of proteolytic enzymes. During some periods of its development *Triphyophyllum peltatum* is apparently carnivorous. An important source of nutrients is thus tapped which may facilitate the transition from the juvenile to the rapidly-climbing adult form of the plant.

In nature, seeds germinate during the peak of the rainy season when the seeds are submerged or resting on the waterlogged forest floor. In cultivation in Sierra Leone the germinating seeds and young seedlings are sensitive to variation in temperature.

The juvenile plant consists of a short shoot growing to a maximum height of 1 m, bearing eglandular, oblanceolate leaves. These are succeeded by 1–6 filiform, glandular leaves, the two types often alternating thereafter. In the natural habitat, glandular leaves are most common on 30–50 cm long shoots. The glandular leaves are held erect, and remain on the plant for a few weeks only. The eglandular leaves tend to persist for several months. A liana is produced from the terminal bud of a juvenile shoot, or from an axillary shoot at the base of an existing liana. The terminal portion of the rachis of the leaves of the liana is prolonged into a pair of strong hooks with which the liana attaches itself to supporting trees. Flowers are usually produced during April and May.

Glandular leaves do not normally occur on undamaged mature plants. However, after a plant has been cut back such leaves may be formed on regeneration. In areas where the forest has been regularly disturbed, many short shoots with glandular leaves are often found arising from the underground parts of damaged plants or from the basal axils of stumps. Glandular leaves are conspicuous on such plants.

Dioncophyllaceae is a small family of the *Caryophyllales* s.l. comprising 3 monotypic genera in tropical West and Central Africa. *Caryophyllales* comprises, among others, several carnivorous families. In the *Dioncophyllaceae,* this character is believed to be secondarily lost, except in *Triphyophyllum peltatum.*

Ecology *Triphyophyllum peltatum* is restricted to an area of rainforest with relatively uniform climatic and soil conditions. Much of the forest is secondary and has been modified over a long period of shifting cultivation. The area has a dry season of 6–7 months, from mid-November to May–June, with 3 months with less than 10 mm rain per month. Peak rainfall (up to 1500 mm per month) is during July and August, but heavy showers occur during June and from September to early November. The soil in the area is rocky and shallow, seldom more than 10 cm deep. The surface soil is acid (about pH 4.2) and poor in mineral nutrients. It is waterlogged during the wet season and relatively arid during the dry. However, fissures in the underlying rock may sometimes allow the roots of the plants to find water.

Management *Triphyophyllum peltatum* is only collected from the wild. A protocol for in-vitro multiplication has been developed.

Genetic resources and breeding *Triphyophyllum peltatum* occurs in a fairly large area and in secondary vegetation. There are no indications that it is under threat of genetic erosion.

Prospects It is unlikely that *Triphyophyllum peltatum* will become more important as a fibre plant. Recent information on its antimalarial and other medicinal properties is promising, but similar chemical compounds from related species, especially from *Ancistrocladus korupensis* D.W.Thomas & Gereau (*Ancistrocladaceae*) seem to have more direct pharmaceutical potential.

Major references Airy Shaw, 1951; Bringmann et al., 1998; Burkill, 1985; Cremers, 1974; Green, Green & Heslop-Harrison, 1979.

Other references Bringmann & Feineis, 2000; Bringmann & Rischer, 2001; Bringmann et al., 1997; Bringmann et al., 1999; Bringmann et al., 2001; Bringmann et al., 2003b; Bringmann et al., 2008; Cuenoud et al., 2002; François et al., 1997; Keay, 1954d.

Authors L.P.A. Oyen

TRIUMFETTA CORDIFOLIA A.Rich.

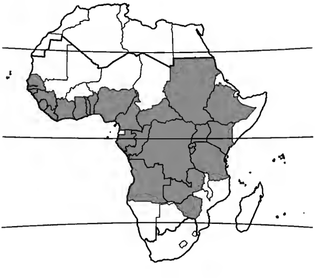
Protologue Fl. Seneg. tent.: 91, t. 18 (1831).

Family Tiliaceae (APG: Malvaceae)

Vernacular names Burweed, cordleaf burbark (En). Mchochokoe (Sw).

Origin and geographic distribution *Triumfetta cordifolia* is widespread in the moister parts of tropical Africa. It is sometimes planted.

Uses The bark of the stem and branches yields a fibre which, in the form of bark ribbons or after retting, is locally used for making strong rope, bowstring and fishing lines. It is sometimes made into belts used for climbing



Triumfetta cordifolia – wild

trees and palms, for instance to collect palm wine. The fibre is locally used for making brooms, bags, baskets, mats, hammocks, and traditional dancing costumes. Commercially it has been used for making burlap cloth, sacks and packaging material. Plant parts are locally used as toothbrushes. The soft leaves have been used as toilet paper.

In DR Congo the wood is used for house construction, and as fuelwood and fire sticks. The bark of green shoots is a source of mucilage used for making soups and sauces with a sticky consistency. The mucilage obtained from *Triumfetta* species is often used as baby food and for young children not yet able to eat coarse starchy foods. Because of its high energy value, the soup is often the first dish given to women who have delivered a child. It is also used as appetizer. The leaf is commonly eaten as a cooked vegetable. In Tanzania the tender leaf is chopped and cooked alone or mixed with other vegetables, after which coconut milk or pounded groundnuts are added, and it is served with 'ugali', rice, potatoes or bananas. Ash from the burnt leaf of *Triumfetta cordifolia* has been used for making soap and in the indigo industry in Guinea. The shrub is browsed by livestock, and it is a good source of nectar and pollen for bees.

Triumfetta cordifolia is widely used in African traditional medicine. Root preparations are applied on burns, and the powdered root is mixed into food for the treatment of diarrhoea. The sap of the root or leaf, diluted with water, is taken to ease childbirth, to expel the placenta, and for treatment of sterility in women. A maceration of the bark is taken against lumbago and muscle pain. Palm wine in which the pounded bark has been steeped is drunk for the treatment of lung problems. A decoction of the twigs with sugar is taken for the treatment of dyspnoea and intercostal neuralgia. In case of insanity or possession, the sap of leafy twigs is drunk and the body sprinkled with it. Young shoots are made into dressings for wounds to keep away insects. The leaf is used in preparations to treat diarrhoea and dysentery. Softened leaves are rubbed on against lumbago, and warmed leaves are rubbed on the gums against caries. A leaf decoction is taken against rhinitis, as a galactagogue and to induce labour, and applied as a wash against vaginal prolapse. A decoction of the leaf or leaf sap is drunk to cure diseases of the liver, lumbago and muscle pain, or as a laxative. The leaf sap or an infusion or maceration of the leaf is drunk to expel the placenta. A leaf extract is taken for the treatment of asthenia, marasmus, hepatitis and dysentery. An infusion of the flower is applied in enemas as a purgative, and ground flowers are steeped in water which is taken against nausea. In veterinary medicine the leaf sap is given for the treatment of diarrhoea.

Production and international trade *Triumfetta cordifolia* is mainly used locally. In DR Congo it has sometimes been an important item of commerce, and retted fibre was exported, mixed with that from *Clappertonia polyandra* (K.Schum.) Bech. In 1950 about 3000 kg of this fibre mixture was exported to Belgium, where it was used for making sacks and packaging material.

Properties The fibre is durable and water resistant. It has the right balance between stiffness and elasticity to tie bundles into brooms. Fibre obtained from the branches is less flexible and more fragile than that from the stem. Fibre from Ghana examined in the early 20th Century was judged to be of equal quality to the finest grades of jute; strands were 1.5 m long, pale buff in colour, fine, of even diameter, strong, soft and lustrous. Later tests indicated that the fibre is comparable to jute in length and strength, but less fine and flexible.

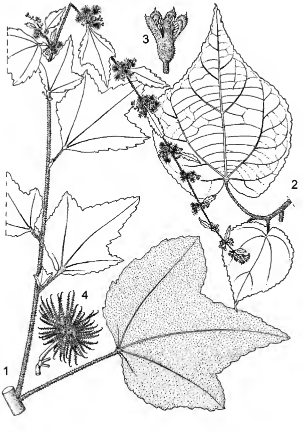
The stem is mucilaginous and recorded to be pungent. The stem contains ceramides (triumfettamide and triumfettoside Ic), heptadecanoic acid, β-sitosterol glucopyranoside, friedelin, lupeol, betulin, maslinic acid, 2-hydroxyoleanolic acid and the mixture of stigmasterol and β-sitosterol. Maslinic acid and an oxidized derivative of betulin (betulinic acid) are known to have anti-HIV activity. An aqueous extract of the stem induced weight loss and showed antihyperlipemic effects in guinea pigs.

The leaf is fragrant when crushed. The nutritional composition of burweed leaves (*Triumfetta* sp.) per 100 g edible portion is: water 78.4 g, energy 285 kJ (68 kcal), protein 4.2 g, fat 0.4 g, carbohydrate 15.2 g, fibre 3.4 g, Ca 392 mg, P 76 mg, Fe 29.2 mg (Leung, Busson & Jardin, 1968). Saponin is reported present throughout the plant. The plant is said to be resistant to fire and to have potential to be used in firebreaks.

Adulterations and substitutes The fibre is comparable to that of *Clappertonia polyandra*, but coarser than Congo jute (*Urena lobata* L.). Other *Triumfetta* species, such as *Triumfetta rhomboidea* Jacq. and *Triumfetta tomentosa*

Bojer, yield fibres used locally for similar purposes. The leaves of related species such as *Triumfetta annua* L., *Triumfetta pentandra* Guill., Perr. & A.Rich. and *Triumfetta rhomboidea* are also used as a cooked vegetable, and their bark as a source of mucilage.

Description Shrub up to 2.5(–5) m tall; stem 1.5 cm in diameter at base, sparsely branched; bark smooth, red-brown, in younger stems subscabrous to softly velvety with brownish hairs. Leaves alternate, simple; stipules triangular, 4–17 mm long, densely stellate-hairy; petiole terete, up to 13.5 cm long, hairy as stem; blade elliptical to almost orbicular, 4.5–20 cm × 2–18 cm, almost unlobed to 3(–5)-lobed with a central lobe 2.5–4.5 cm long and lateral lobes 0.5–2.5 cm long, base cordate, rarely obtuse, apex acuminate to acute, margin doubly toothed, usually discolorous, upper surface with minute, thinly scattered stellate hairs, lower surface sparsely hairy or densely covered with soft stellate hairs with a few longer simple hairs, greyish or brownish white. Inflorescence terminal, with 5–10 ultimate branches 5–35 cm long, each with nodes 8–20 mm apart, each node bearing 3–10 cymes, lower nodes with reduced leaves, cymes 1–3-flowered; peduncle 4–11 mm long; bracts triangular, 1.5–5 mm long, densely stellate-hairy. Flowers bisexual, regular; pedicel up to 3 mm long; sepals 5, free, narrowly oblanceolate, up to 11 mm long, with an extremely short apical spine, outer surface densely brownish-grey stellate-hairy to almost glabrous; petals 5, oblong to almost orbicular, 5–7 mm × 2–3 mm, white, yellow or orange, with basal claw 1–2 mm long, margin densely woolly hairy; stamens 8–12; ovary superior, 4–5-locular. Fruit a dehiscent, almost spherical capsule 7–15 mm in diameter (including bristles), dark brown, glossy and glabrous or with sparse simple hairs (rarely dense), with c. 80 patent bristles 3–4 mm long, apex of bristles tightly hooked, with a single terminal hair. Seeds c. 2 mm long.



Triumfetta cordifolia – 1, flowering and fruiting branch; 2, leafy twig; 3, flower; 4, fruit. Redrawn and adapted by Achmad Satiri Nurhaman

Other botanical information *Triumfetta* is a pantropical genus of about 100 species. The classification within *Triumfetta* is mainly based on fruit characteristics. Within *Triumfetta cordifolia* several varieties are distinguished. *Triumfetta cordifolia* var. *cordifolia* has an unlobed leaf blade, with sparse indumentum consisting mainly of stellate hairs. Var. *tomentosa* Sprague has a markedly 3(–5)-lobed leaf blade, with dense greyish white tomentellum on the lower surface. Var. *hollandii* Sprague has an unlobed or 3-lobed leaf blade, with numerous long simple hairs and small stellate ones.

Growth and development *Triumfetta cordifolia* grows fast. In Benin flowering is in May–February and fruiting in January–March. The fruits stick to the fur of animals that disperse them. They are also dispersed by elephants which swallow the fruits when they browse the foliage.

Ecology *Triumfetta cordifolia* occurs from sea-level up to 2650 m altitude, and is locally common in wooded grassland, secondary forest, edges and clearings of wet forest, riverine forest, marshy locations, fallows, roadsides and disturbed land. It is a common weed in cultivated land and not easy to eradicate.

Propagation and planting *Triumfetta cordifolia* can be propagated by seed. A germination rate of 80–90% is normal. Cuttings from leafy stems can also be used for propagation. When *Triumfetta* species are cultivated for the mucilage, cuttings of 15–20 cm long are taken from the top end of the harvested stems. Since the crop does not perform well under direct sunlight, the cuttings are usually planted in the shade of a tree. They are planted in a circle with a spacing of 10–15 cm. If the cutting is not planted straight upward, adventitious roots may develop, causing a reduced capacity to produce slime. Therefore, some farmers tie the cuttings to a taller plant, e.g. plantain, to ensure that they grow upright.

Management Earthing up, mulching and shading are recorded to have beneficial effects on the growth of *Triumfetta cordifolia*. The management of *Triumfetta* plants cultivated for mucilage is restricted to weeding, provision of support and some irrigation during periods of drought.

Diseases and pests *Triumfetta cordifolia* is a host plant of the cotton stainer *Dysdercus superstitiosus*, a pest of cotton.

Harvesting At harvesting the stems are cut, leaving 1–2 buds at the base. Stems can be harvested from the same plant for many years. Stems for mucilage are cut just above ground level when they are 75–100 cm long. They are prepared by removing all leaves and the terminal part where the stem has a diameter of less than 1 cm. The resulting sticks are either taken to the homestead or tied into bundles and brought to the market. Leaves to be eaten as a vegetable are collected during the rainy season.

Yield In DR Congo yields of about 260 kg dry fibre per ha have been obtained after 13 days of retting. In Equatorial Guinea 600 kg of stems yielded about 100 kg of bark, from which about 10 kg of yarn could be obtained.

Handling after harvest Removing the bark from the stem requires some force. To obtain the fibre, the stem may be retted in water for several days. It takes more time in running water than in stagnant water, but the fibre obtained after soaking in running water has a lighter colour and better quality. It is difficult to extract the fibre from dry stems.

Mucilage is extracted by softening the bark in hot water, followed by kneading it in a small amount of clean water. During kneading, the mucilage is released into the water, which is added to stews to make them sticky. Bark peeled from the stem can be stored.

Genetic resources In view of its wide distribution and broad range of habitats, *Triumfetta cordifolia* is not threatened by genetic erosion.

Prospects *Triumfetta cordifolia* is a useful local source of various materials, including strong fibre, edible leaves, mucilage and medicines. The medicinal uses are widely known in tropical Africa, but its value as a fibre plant is not always known, which is limiting its actual use. *Triumfetta cordifolia* seems to have potential as a fibre plant, as it is widespread and common in the more humid parts of tropical Africa, and reports on the fibre properties are positive. Most of the information on the fibre properties is old, however, and renewed research is needed to assess the potential of this species for modern applications.

Major references Baerts & Lehmann, 1989; Burkill, 2000; Dubois, 1951; Kirby, 1963; Latham, 2004; Neuwinger, 2000; Ruffo, Birnie & Tengnäs, 2002; Schippers, 2000; Terashima, Kalala & Malasi, 1991; Whitehouse et al., 2001.

Other references Adjanohoun et al. (Editors), 1988; Adjanohoun et al., 1991; Akoègninou, van der Burg & van der Maesen, 2006; Banderembako & Ntitangirageza, 1978; Bouquet, 1969; Friis & Vollesen, 1998; Goulding, 1917; Hamill et al., 2000; Irvine, 1961; Kokwaro, 1993; Lejeune, 1953; Leung, Busson & Jardin, 1968; Mauersberger (Editor), 1954; Nava, 1951; Ngondi et al., 2006; Sandjo et al., 2008; Vergiat, 1970a; White & Abernethy, 1997; Wilczek, 1963; Wome, 1985.

Sources of illustration Busson, 1965.

Authors R.B. Jiofack Tafokou

TRIUMFETTA PENTANDRA A.Rich.

Protologue Fl. Seneg. tent.: 93, t. 19 (1831).

Family Tiliaceae (APG: Malvaceae)

Vernacular names Fivestamen burbark (En).

Origin and geographic distribution *Triumfetta pentandra* is pantropically distributed. It is widespread throughout the drier parts of tropical Africa, from Cape Verde, Mauritania and Senegal eastward to Eritrea and Ethiopia, and southward to Namibia, Botswana, Zimbabwe, Mozambique, Madagascar, Réunion and Mauritius.

Uses The bark is a source of fibre used for making string and fishing line. The bark of green shoots is a source of mucilage used for making sticky soups and sauces. The leaf is eaten as a cooked vegetable. The plant yields fodder of mediocre quality. In Congo fresh root scrapings are applied on sores and small wounds. The crushed leaf is applied in dressings for treatment of goitre and deformities. In veterinary medicine in Burundi leaf sap is given for treatment of theileriosis.

Properties Reports on the quality of the fibre are not consistent. The fibre has been recorded to be of average quality only, but in

India it is recorded to be soft, spinnable and nearer to jute in quality than *Triumfetta rhomboidea* Jacq.

Botany Erect, annual herb up to 2 m tall; stem often woody at the base, succulent, reddish or green, stellate-scabrid to hairy. Leaves alternate, simple; stipules narrowly triangular, up to 7 mm long, dark brown, hairy; petiole up to 10 cm long, hairy; blade elliptical to rhombic-orbicular, sometimes wider than long, 1–12 cm × 0.5–9 cm, unlobed or shallowly 3-lobed to 1/5 of the base, with lateral lobes sometimes slightly diverging, base rounded to cuneate, apex acute to acuminate, margin 1(–2)-toothed, membranous, upper surface softly hairy to subscabrid to glabrous, lower surface softly stellate hairy to subscabrid, with crater-like elliptical glands. Inflorescence terminal, many-branched, up to 45 cm long, lower nodes with slightly reduced leaves, becoming more linear and reduced towards the top, nodes 1.5–4 cm apart, each with 1–5 cymes, cymes 1(–3)-flowered; peduncle up to 3 mm long, hairy as stem; bracts narrowly triangular, 1.5–2 mm long. Flowers bisexual, regular; pedicel up to 3 mm long; sepals 5, free, elliptical-linear, 2–4 mm long, sparsely stellate-hairy outside, with apical spine 0.5 mm long; petals 5, free, spoon-shaped, 3–3.5 mm × 0.5–1 mm, yellow or green, with basal claw, lower 0.5 mm of the claw sparingly hairy at the margin; stamens 5(–13); ovary superior, 2-celled, sparsely hairy. Fruit an indehiscent, ovoid capsule 4–10 mm × 3–6 mm (including spines), with 65–90 forward pointing dark brown spines, each usually glabrous apart from a line of glistening white hairs and each with a translucent, forward directed recurved hair at the tip, 2–4-seeded. Seeds 1.5–2.5 mm long.

In Benin *Triumfetta pentandra* flowers in September and bears fruits in October.

Triumfetta is a pantropical genus of about 100 species. The classification within *Triumfetta* is mainly based on fruit characteristics. *Triumfetta pentandra* is closely related to *Triumfetta rhomboidea* Jacq., and the two species are difficult to distinguish in the vegetative stage, although *Triumfetta rhomboidea* often has a more deeply 3-lobed leaf blade with a more thickly tomentose lower surface. In the generative stage *Triumfetta pentandra* is easily distinguished by its flower usually having only 5 stamens and its fruit being ovoid and usually glabrous. However, *Triumfetta pentandra* var. *homoiotrichia* Chiov., only known from Somalia, has flowers with 13 stamens and fruits with spines hairy all over.

Ecology *Triumfetta pentandra* occurs from sea-level up to 1700 m altitude, in gallery forest, woodland, grassland, marshy locations, old cultivations and disturbed locations, often in partial shade. It is a weed in cultivated land. In northern Cameroon its presence is sometimes an indicator of degraded soils.

Management In northern Burkina Faso *Triumfetta pentandra* is locally grown as an intercrop of pearl millet. When *Triumfetta* species are cultivated for the mucilage, cuttings of 15–20 cm long are taken from the top end of the harvested stems. Since the crop does not perform well under direct sunlight, the cuttings are usually planted in the shade of a tree. They are planted in a circle with a spacing of 10–15 cm. If the cutting is not planted straight upward, adventitious roots may develop, causing a reduced capacity to produce slime. Therefore, some farmers tie the cuttings to a taller plant, e.g. plantain, to ensure that they grow upright. Further management of *Triumfetta* plants cultivated for mucilage is restricted to weeding and some irrigation during periods of drought. Stems for mucilage are harvested by cutting them just above ground level when they are 75–100 cm long. They are prepared by removing all leaves and the terminal part where the stem has a diameter of less than 1 cm. The resulting sticks are either taken to the homestead or tied into bundles and brought to the market.

Genetic resources and breeding In view of its wide distribution and broad range of habitats, *Triumfetta pentandra* is not threatened by genetic erosion.

Prospects *Triumfetta pentandra* is a local source of fibre, mucilage, fodder and medicine. Consistent and detailed information on the fibre properties is lacking, making it difficult assess the prospects of this species as a fibre plant.

Major references Burkill, 2000; Schippers, 2000; Vergiat, 1970a; Vollesen & Demissew Sebsebe, 1995; Whitehouse et al., 2001.

Other references Akoègninou, van der Burg & van der Maesen, 2006; Bigendako-Polygenis & Lejoly, 1990; Bosser, 1987; CSIR, 1976; Leenders, 2006; M'Biandoun, Guibert & Olina, 2006; Sebsebe Demissew, 1999; Westphal, 1981; Wilczek, 1963; Wild, 1984.

Authors M. Brink

TRIUMFETTA PILOSA Roth

Protologue Nov. Pl. Sp.: 223 (1821).

Family Tiliaceae (APG: Malvaceae)

Chromosome number $2n = 64$

Synonyms *Triumfetta abyssinica* K.Schum. (1892).

Vernacular names Hairy ropebark (En).

Origin and geographic distribution *Triumfetta pilosa* is widespread in tropical Africa, from southern Sudan, Ethiopia and Eritrea southward to Zimbabwe, Mozambique and Madagascar. It also occurs in South Africa and Swaziland, and in tropical Asia.

Uses The stem bark is much used for making rope and string. It is made into barkcloth by hunter-gatherers in DR Congo. In India the partially retted fibre is made into canvas and sailcloth, because of its durability in moist conditions.

In Madagascar a leaf infusion is drunk to treat colic and diarrhoea, whereas in East Africa an extract of the leaf is recorded to be drunk as a purgative. In South Africa a leaf maceration is used as an eye bath for treatment of eye problems. In India the bark and fresh leaf are used for the treatment of diarrhoea, the leaf and flower for the treatment of leprosy, and the crushed leaf and twig are applied as a paste on sores.

Properties Fibre strands are 25–40 cm long, white and very soft. The individual fibre cells are on average 1.5 mm long and 11.3 μm wide. The fibre contains about 85% cellulose, 14% lignin and 1% ash.

The seed contains 12% oil. The main fatty acids are palmitic acid (17%), stearic acid (11%), oleic acid (20%) and linoleic acid (43%). The oil also contains the cyclopropenoid fatty acids malvalic acid (2%) and sterculic acid (7%), which are known to cause abnormal physiological reactions in animals. Therefore the seeds are not suitable for consumption unless the cyclopropenoid acids have been removed.

Botany Perennial herb or shrub up to 3 m tall, often weak-stemmed and straggling or scandent; stem terete, 4–7 mm in diameter, moderately clothed with rigid reddish hairs up to 1.5 mm long having, towards the base of the stem, black bases which become prickle-like, rarely with stellate hairs without aculeate bases. Leaves alternate, simple; stipules triangular, up to 8 mm long, dark brown, densely clothed with brownish hairs, often persistent; petiole terete, up to 6 cm long, densely clothed with brownish hairs; blade ovate to lanceolate, unlobed, 3–13(–20) cm × 1–7(–9.5) cm, base obtuse to cordate, apex acute to acuminate, margin coarsely toothed, lower side pilose, upper side with shorter and sparser hairs. Inflorescence terminal, 5–35 cm long, bearing slightly reduced leaves, nodes 1–3.5 cm apart, each with 1–4(–5) cymes, cymes (1–)3-flowered; peduncle up to 1 cm long, hairy as petiole; bracts narrowly triangular-ovate, 2–4(–6) mm long. Flowers bisexual, regular; pedicel up to 5 mm long; sepals 5, free, narrowly lanceolate, slightly fiddle-shaped, 5–10 mm long, thickly covered with stellate hairs, sometimes glabrescent, with horn up to 1 cm long; petals 5, rounded-oblong, 5–7(–11) mm × 1.5–3(–4) mm, yellow, with basal claw, base of the claw with densely hairy margin; stamens 9–11(–15); ovary superior, 3–4-locular. Fruit a dehiscent globose capsule (12–)15–27 mm in diameter (including bristles), with 72–100 dark brown rigid bristles up to 10(–11) mm long, densely clothed in long, simple hairs, rarely glabrous, apex of bristles hooked, with a single terminal hair. Seeds c. 3 mm long.

Triumfetta is a pantropical genus of about 100 species. The classification within *Triumfetta* is mainly based on fruit characteristics. *Triumfetta pilosa* is easily confused with *Triumfetta tomentosa* Bojer, but can be distinguished from the latter by its larger fruit with bristles strongly hooked at the tip. In the absence of fruits the two species are more difficult to distinguish, but the leaf blade of *Triumfetta tomentosa* is usually wider, sometimes 3-lobed, and has a denser and shorter indumentum, whereas the stem lacks the black, aculeate hair-bases often found in *Triumfetta pilosa*.

Triumfetta pilosa is an extremely variable species, and several varieties have been distinguished:

- var. *effusa* (E.Mey. ex Harv.) Wild: leaf blade ovate from sparsely stellate pubescent to densely stellate-tomentose, especially below; bristles on fruits glabrous or with few hairs near the base; distributed in Malawi, Zambia, Zimbabwe, Mozambique, South Africa and Swaziland.
- var. *glabrescens* Sprague & Hutch.: leaf blade oblong-lanceolate or elliptical, 8–14 cm × 1.5–6 cm, often only sparingly stellate-hairy; calyx glabrescent; distributed in Uganda, Tanzania, Malawi, Zambia, Zimbabwe and Mozambique.
- var. *pilosa* (synonym: *Triumfetta pilosa* var. *nyasana* Sprague & Hutch.): leaf blade lanceolate, 6.5–18 cm × 1–7 cm, pilose beneath,

hairs largely simple; calyx more or less thickly covered with stellate hairs; distributed in tropical Africa and Asia.

- var. *tomentosa* Szyszyl. ex Sprague & Hutch.: leaf blade ovate, 6–12 cm × 3–7.5 cm, densely and shortly stellate-hairy above, more densely so beneath; bristles on fruits pilose; distributed in Malawi, Zambia, Zimbabwe, Mozambique, South Africa and Swaziland.

Ecology *Triumfetta pilosa* occurs at 1000–2550(–2750) m altitude in forest, woodland and grassland, in swamp edges or on stream banks, along roads, in fallows and as a weed. In the Amhara region of Ethiopia *Triumfetta pilosa* is an indicator of increasing fertility in wetlands, and its appearance makes farmers put back a fallow under cultivation. The seeds stick to animals, which then disperse them.

Management The stem yields about 7% fibre.

Genetic resources and breeding Because of its widespread distribution, broad range of habitats, and occurrence as a weed in cultivated land, *Triumfetta pilosa* is not threatened by genetic erosion.

Prospects *Triumfetta pilosa* is a useful local source of fibre, much used in Africa as well as in Asia. Information on the fibre properties is scarce, however, making it difficult assess the prospects of this species.

Major references Boiteau, Boiteau & Allorge-Boiteau, 1999; CSIR, 1976; Hosamani & Ramesh, 2003; Whitehouse et al., 2001; Wild, 1984.

Other references Begum & Nath, 2000; Capuron, 1963; Dixon, 2001; Friis & Vollesen, 1998; Kokwaro, 1993; Neuwinger, 2000; Schmidt, Lötter & McCleland, 2002; Terashima & Ichikawa, 2003; Vollesen & Demissew Sebsebe, 1995; Wilczek, 1963.

Authors M. Brink

TRIUMFETTA RHOMBOIDEA Jacq.

Protologue Enum. syst. pl. 22 (1760).

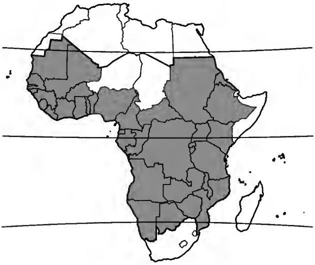
Family Tiliaceae (APG: Malvaceae)

Chromosome number $2n = 32$, (48)

Synonyms *Triumfetta bartramia* L. (1759).

Vernacular names Burbush, burweed, Chinese bur, diamond burbark, paroquet bur (En). Herbe à paniers, hérisson blanc (Fr). Mchokochole, mchokochore, mfyokochore (Sw).

Origin and geographic distribution *Triumfetta rhomboidea* is a pantropical weed. It is very widespread in continental Africa, including South Africa. It is introduced and naturalized in Cape Verde, Madagascar, Seychelles, Réunion and Mauritius and in Australia.



Triumfetta rhomboidea – wild

Uses The bast fibre of *Triumfetta rhomboidea* (known as 'punga' in DR Congo and Angola) is used throughout its range for making rope, string, ties and thread. In Nigeria game and fishing nets are made from the fibre. In Gabon it is used for tying the thatch of hut-roofs. The twigs are used for making fish-traps and in basketry. In East Africa they are used as chew-sticks. The leaves are used for cleaning metal objects such as gun-barrels and the larger ones are used in Tanzania as toilet paper.

The mucilaginous leaves serve as a pot-herb and famine food in Africa and India, and are widely used as fodder. The bark of green shoots is a source of mucilage used for making soups and sauces with a sticky consistency. The mucilage obtained from *Triumfetta* species is often used as baby food and for young children not yet able to eat coarse starchy foods. Because of its high energy value, the soup is often the first dish given to women who have delivered a child. It is also used as appetizer. The boiled roots are eaten as a vegetable, for instance in Zimbabwe.

In traditional African medicine the stems and leaves are widely used as emollients and for treating skin-complaints of children, burns, eczema, scabies and to mature abscesses and furuncles. In Côte d'Ivoire and Burkina Faso leaf infusions are given to children to bring down fever and to prevent diarrhoea. A decoction of the leaves is used against dysentery. In Gabon and DR Congo an infusion of the leaves is used as a cure for colic. This infusion is also drunk in DR Congo as a cure for leprosy. In Rwanda the leaves are used as a cure for angina and pneumonia and they are used for deworming. Snakebites are treated with the leaves in Rwanda and the pulped root in Tanzania. In East Africa the root is used as painkiller, especially against headache, toothache and circumcision wounds. In Madagascar the roots are used for the treatment of conjunctivitis. In Mauritius a decoction of leaves and roots is drunk against coughing and a decoction of the roots alone in case of poisoning by poisonous fish. Parts of the plant are used in Uganda (leaves and roots) and South Africa (fruit and roots) to facilitate and hasten childbirth.

In traditional veterinary medicine in Nigeria the leaves are fed to horses to cure internal troubles, including worms. In Sierra Leone the seeds are mixed with sorghum and fed to horses against constipation and worms.

Production and international trade *Triumfetta rhomboidea* is only used and traded at the local level.

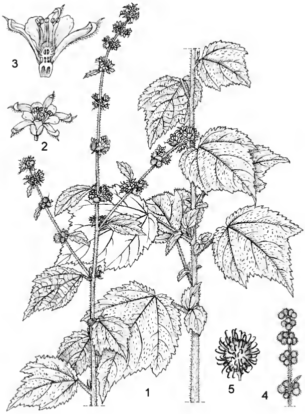
Properties The bast fibre cells are polygonal in cross-section, 1.1–2.8 mm long and 9–27 µm wide. Bast fibre from Uganda investigated in the 1930s contained 60% cellulose and 11% lignin.

In the dry season in central Kenya the leaves contain per 100 g dry matter: 17.9 g crude protein, 46.1 g neutral detergent fibre, 9.0 g ash and 8.4 g soluble tannins, with an in-vitro dry matter digestibility of 65%, and an in-vitro crude protein digestibility of 87%. In the rainy season the leaves contain per 100 g dry matter: 17.8 g crude protein, 36.1 g neutral detergent fibre, 7.6 g ash and 19.8 g soluble tannins, with an in-vitro dry matter digestibility of 66%, and an in-vitro crude protein digestibility of 87%.

Quite some work has been done in recent years on the phytochemistry and biological activities of *Triumfetta rhomboidea*. Triumferol (4-hydroxy-isoxazole) was isolated from the plant. Water and ethanol extracts, containing triumferol, were tested for their anti-implantation effects by oral administration to rats over a 10-day period after mating, and were found to interrupt pregnancy in a dose-dependent manner. The compound is also an effective seed-germination inhibitor. Analgesic and anti-inflammatory effects of the methanolic extract of the leaves have been confirmed by laboratory tests. Extracts from the leaves have shown antiviral activity against Coxsackie virus. The essential oil of the aerial parts has been analysed and antibacterial activity assessed. The main constituents identified were β-caryophyllene (22.4%), kessane (14%) and caryophyllene oxide (13%). Antimicrobial tests showed a mild activity against *Escherichia coli* and *Enterococcus hirae*. Antimicrobial tests of water and ethanol extracts of the aerial parts have shown a moderate activity against *Bacillus cereus, Escherichia coli, Enterococcus faecalis, Klebsiella pneumoniae, Pseudomonas aeruginosa* and *Staphylococcus aureus*. The crude extract of the aerial parts significantly inhibits the activity of angiotensin converting enzyme (ACE) in vitro. This is one of the enzymes involved in blood pressure regulation. Phytochemical analysis revealed the presence of the flavone glycoside triumboidin (scutellarein-6-xyloside-7-rhamnoside), rosmarinic acid, friedelin and friedelinol in the leaves. The seeds have a strong purgative activity and other plan parts are used as a purgative as well.

Adulterations and substitutes The fibres of *Sida rhombifolia* L. are used in the same way as those of *Triumfetta rhomboidea*. A very similar fibre, also known as 'punga', is obtained from *Clappertonia ficifolia* Decne. The roots and leaves of *Abutilon, Sida, Urena* and other species of *Triumfetta* in decoction are also used as emollients.

Description Annual herb or perennial shrub up to 200 cm tall; stem erect, up to 1 cm in diameter at the base; bark smooth, red-brown, scabrid, hairy or glabrous. Leaves alternate, simple; stipules narrowly elliptical to linear, up to 4 mm × 1 mm, black, falling early; petiole terete, up to 7 cm long, densely hairy; blade rhombic, elliptical or ovate, 2.5–11.5(–17) cm × 2.5–8(–10.5) cm, usually 3-lobed halfway or three-quarter to base, rarely entire, base cuneate to obtuse, apex acute or shortly acuminate, margin singly or doubly toothed, upper surface with scattered hairs, lower surface densely hairy. Inflorescence terminal, with 1–4 ultimate branches, 5–35 cm long, each with nodes 15–40 mm apart, each node bearing 1–6 cymes, nodes with reduced leaves becoming more linear and smaller towards the top, cymes (1–)3(–5)-flowered; peduncle 2–3 mm long; bracts narrowly elliptical to linear, up to 4 mm × 1 mm. Flowers bisexual, regular; pedicel up to 2 mm long; sepals 5, free, narrowly elliptical to linear, 8–9 mm long, with apical spine up to 0.5 mm long, outer surface sparsely brownish-grey stellate-hairy, red in bud; petals 5, spatulate, 5–7 mm × 1.5–2 mm, white, yellow or orange, with basal claw 1 mm long, hairy; stamens



Triumfetta rhomboidea – 1, flowering branch; 2, flower; 3, flower in longitudinal section; 4, part of fruiting branch; 5, fruit.
Source: PROSEA

(14–)15; ovary superior, 4–5-locular, sparsely hairy. Fruit a dehiscent, almost spherical capsule 5–7.5 mm × 4–5 mm (including bristles), dark brown, glossy and with dense, long, simple brownish-white hairs with c. 65–90 patent bristles 3–4 mm long, apex of bristles tightly hooked, with a single terminal recurved hair, (2–)4(–6)-seeded. Seeds semi-ovoid, 2–2.5 mm long. Seedling with epigeal germination.

Other botanical information *Triumfetta* comprises about 70 species with a tropical distribution, and several of these are pantropical weeds. *Triumfetta rhomboidea* exhibits a lot of variation but the fruits are uniform and diagnostic. In the vegetative state, *Triumfetta rhomboidea* is difficult to distinguish from the closely related *Triumfetta pentandra* A.Rich. It is also easily confused with *Urena lobata* L., but the latter has 1–3 nectaries at the base of the main veins on the lower side of the leaf.

Growth and development In West Africa *Triumfetta rhomboidea* flowers in August–December. Flowers are visited by bees. The fruits cling to fur or clothes and are thus dispersed.

Ecology *Triumfetta rhomboidea* is common along roadsides, in waste places and in other ruderal locations, up to 2750 m altitude.

Propagation and planting When *Triumfetta* species are cultivated for the mucilage, cuttings of 15–20 cm long are taken from the top end of the harvested stems. Since the crop does not perform well under direct sunlight, the cuttings are usually planted in the shade of a tree. They are planted in a circle with a spacing of 10–15 cm. If the cutting is not planted straight upward, adventitious roots may develop, causing a reduced capacity to produce slime. Therefore, some farmers tie the cuttings to a taller plant, e.g. plantain, to ensure that they grow upright. Propagation with seed is possible as well.

Management Pollarding is possible, but regrowth is slow. Attempts have been made in Malawi to cultivate *Triumfetta rhomboidea* for fibre production but apparently the trials have been discontinued without the results having been published.

Diseases and pests No serious diseases and pests are recorded for *Triumfetta rhomboidea*. It is sometimes attacked by the fungus *Corynespora*, by fungi causing powdery mildew, and also by a geminivirus, causing yellow netting on the leaves. It is an important alternative host for insect pests of jute (*Corchorus* spp.).

Harvesting *Triumfetta rhomboidea* is collected from the wild whenever the need arises. Stems for mucilage are cut just above ground level when they are 75–100 cm long.

Yield Fresh stems contain about 3% fibre, air-dry stems about 8%. Dry ribbons contain about 26% fibre. In the 1960s fibre yields of cultivated *Triumfetta rhomboidea* were estimated at 500–800 kg/ha.

Handling after harvest The fibre is extracted by retting in running or stagnant water. Alternatively, bark ribbons are stripped from the stem and scraped with a knife to remove extraneous matter, after which they are ready for use. Mucilage is extracted by softening the bark in hot water, followed by kneading it in a small amount of clean water. During kneading, the mucilage is released into the water, which is added to stews to make them sticky.

Genetic resources *Triumfetta rhomboidea* is widely distributed in anthropogenic habitats and does not seem to be at risk of genetic erosion.

Breeding No breeding programmes involving *Triumfetta rhomboidea* are known to exist.

Prospects Work on infra-specific classification of *Triumfetta rhomboidea* may prove useful. Preliminary investigations have shown interesting biological effects of extracts (ACE-inhibition) and isolated compounds (triumferol). More research is needed, however, to fully evaluate their potential.

Major references Aguilar, 2001b; Burkill, 2000; Cos et al., 2002; Kirby, 1963; Neuwinger, 2000; Schippers, 2000; Whitehouse et al., 2001; Wild, 1963.

Other references Abbiw, 1990; Bapuji & Ratnam, 2009; Debray, Jacquemin & Razafindrambao, 1971; Devmurari, Ghodasara & Jivani, 2010; Fleuret, 1980; Hansen et al., 1995; Heine & Legère, 1995; Irvine, 1961; Kamatenesi-Mugisha & Oryem-Origa, 2007; Latham, 2005; Mendiola, 1917; Mevy et al., 2006; Nair et al., 1986; Norman, 1937; Portères, 1974; Roecklein & Leung (Editors), 1987; Rootaert, 2000; Uche & Ezugwu, 2009; Uche & Okunna, 2009; Vlietinck et al., 1995.

Sources of illustration Aguilar, 2001b.

Authors C.H. Bosch

Based on PROSEA 12(2): Medicinal and poisonous plants 2.

TRIUMFETTA TOMENTOSA Bojer

Protologue Hort. Maurit.: 43 (1837).

Family Tiliaceae (APG: Malvaceae)

Vernacular names Tomentose burbark (En).

Origin and geographic distribution *Triumfetta tomentosa* is widespread in tropical Africa, from Gambia eastward to Ethiopia and southward through Central and East Africa to Namibia, Zimbabwe, Mozambique and Madagascar. It also occurs in South Africa, tropical Asia and tropical America. It has been cultivated in Mauritius for its fibre.

Uses Fibre from the bark of the lower part of the stem is widely used in tropical Africa for making very good, strong rope and string. In Kenya it is used for tying in hut construction, and in Burundi for weaving mats.

The stem and green bark are a source of mucilage used for making slimy soups and sauces in Cameroon. In central Kenya the twigs and leaves are fed to cattle and goats, and the wood is used as fuel.

A decoction of the leaf is used for washing the stomach after childbirth in Cameroon, and in Burundi a leaf extract is taken for treatment of dysentery. The powdered dry leaf is made into a paste applied on burns in Ethiopia, and is mixed with castor oil and rubbed in against scabies in Tanzania.

Properties Bast fibre from Uganda investigated in the 1930s contained 71% cellulose and 9% lignin.

In the dry season in central Kenya the leaves contain per 100 g dry matter: 15.2 g crude protein, 47.6 g neutral detergent fibre, 9.3 g ash and 7.8 g soluble tannins, with an in-vitro dry matter digestibility of 59%, and an in-vitro crude protein digestibility of 82%. In the rainy season the leaves contain per 100 g dry matter: 26.3 g crude protein, 35.9 g neutral detergent fibre, 11.0 g ash and 8.2 g soluble tannins, with an in-vitro dry matter digestibility of 70%, and an in-vitro crude protein digestibility of 93%. Leaves in Uganda have a crude protein content of 24.7–26.0 g per 100 g dry matter.

Botany Shrub up to 3 m tall; stem erect, 3.5–7 mm in diameter, with a brown, downy cover of mainly stellate hairs. Leaves alternate, simple; stipules narrowly triangular, c. 7 mm long, dark brown, densely hairy; petiole terete, up to 7 cm long, hairy as stem; blade oblong to ovate, 4–14 cm × 1.5–9.5 cm, in lowest leaves slightly 3-lobed with a central lobe c. 3 cm long and lateral lobes c. 0.5 cm long, base cordate to obtuse, apex acute to almost acuminate, margin toothed, lower surface densely covered with a soft tomentose down of white stellate hairs, upper surface with sparse hairs with fewer and shorter arms. Inflorescence terminal, sparsely branched, 10–22 cm long, lower nodes with slightly reduced leaves, nodes 0.5–3 cm apart, each with 6–10 cymes, cymes 1–3-flowered; peduncle up to 5 mm long, hairy as stem; bracts narrowly ovate, 1.5–4 mm × c. 0.5 mm, hairy. Flowers bisexual, regular; pedicel up to 5(–12) mm long; sepals 5, free, narrowly lanceolate to oblong, slightly fiddle-shaped, 4.5–9(–10) mm long, with apical spines, densely grey stellate-hairy; petals 5, rounded-oblong, 4–7(–8.5) mm × 0.5–1.5(–3) mm, yellow, with basal claw, base of the claw fringed with hairs, pubescent; stamens 8–12; ovary superior, 4-locular. Fruit a dehiscent, almost globose capsule (6.5–)8–20 mm in diameter (including bristles), with 96–140 patent dark brown bristles 2–7 mm long, each covered in soft, white and simple hairs, apex of bristles straight to curved, but not hooked, with a single, often inclined, terminal hair. Seeds c. 2.5 mm long, glossy.

In Benin *Triumfetta tomentosa* flowers and bears fruits in February–September.

Triumfetta is a pantropical genus of about 100 species. The classification within *Triumfetta* is mainly based on fruit characteristics. *Triumfetta tomentosa* is easily confused with *Triumfetta pilosa* Roth, but can be distinguished from the latter and other shrubby *Triumfetta* species by its smaller fruit (less than 15 mm in diameter) with bristles lacking a terminal hook. *Triumfetta pedunculata* De Wild., an erect herb or shrub up to 1.5 m tall occurring in DR Congo, is also recorded to be used as a source of fibre.

Ecology *Triumfetta tomentosa* occurs from sea-level up to 2400 m altitude, in forest, swamp margins, bushland, fallows and along roads. It is a weed of cultivated land.

Management *Triumfetta tomentosa* can be propagated by seeds and cuttings. New shoots are formed when stems are cut, and in Burundi annual harvesting of stems is possible. Farmers practice coppicing in central Kenya as well. To obtain the fibre in Burundi, the entire bark is removed from the harvested stem, after which the inner bark is separated in one piece and dried in the sun. In cloudy weather, drying is over a fire, because delayed drying results in discoloration. The inner bark of older stems cannot be recovered for its whole length. The whole piece of inner bark is used as string or for weaving.

Genetic resources and breeding Because of its widespread distribution, broad range of habitats, and occurrence as weed in cultivated land, *Triumfetta tomentosa* is not threatened by genetic erosion.

Prospects Very good, strong rope is made from the bark fibre, and the plant is also a useful local source of food, fodder, fuel and medicine. However, too little information is available on the properties of the fibre and the other useful products to assess the future prospects of this species.

Major references Burkill, 2000; Nzigidahera, 2007; Roothaert, 2000; Vollesen & Demissew Sebsebe, 1995; Whitehouse et al., 2001.

Other references Akoègninou, van der Burg & van der Maesen, 2006; Bosser, 1987; Brokensha & Riley, 1986; Fisseha Mesfin, 2007; Jiofack et al., 2008; Norman, 1937; Rothman et al., 2006; Rothman et al., 2007; Westphal, 1981; Wilczek, 1963.

Authors M. Brink

TYPHA DOMINGENSIS (Pers.) Steud.

Protologue Nomencl. bot.: 860 (1824).

Family Typhaceae

Chromosome number $2n = 30$

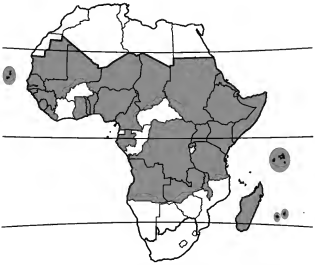
Synonyms *Typha australis* Schumach. (1827), *Typha javanica* Schnizl. ex Rohrb. (1869), *Typha angustifolia* auct. non L.

Vernacular names Bulrush, cattail, Santo Domingo cattail, southern cattail, Indian reedmace (En). Massette australe (Fr).

Origin and geographic distribution *Typha domingensis* is distributed in the subtropical and tropical zones of the world. It is very widespread in tropical Africa. It occurs in several Indian Ocean islands where it possibly has been introduced.

Uses The leaves are widely used in tropical Africa for making mats, hats and baskets. In Gabon they are used as ties in vegetable cultivation. They are recorded to be used for thatching in Ethiopia. The leaves are sometimes used for caulking barrels and to plug seams of canoes. They are also used as bedding for domestic animals and can be used for making paper. The stems are made into mats and fences. In Nigeria the stems are used for making house screens. In Kano State of Nigeria the stems were made into 1-person boats. The mature silky female florets are used for stuffing pillows.

In parts of DR Congo the stems and rhizomes are eaten throughout the year. In other countries, for instance Nigeria, the rhizome is eaten as a famine food. Immature leafy spikes are eaten as a vegetable and the soft core of these spikes is appreciated as a sweet snack. In Argentina the pollen is eaten. *Typha domingensis*



Typha domingensis – wild and naturalized is planted in basins for wastewater treatment in Tanzania, Kenya and in Australia and central and south America. In traditional medicine in Uganda the whole plant is burnt and the ash is licked to cure coughing. Elsewhere it is burnt to obtain salt for cooking or for making soap.

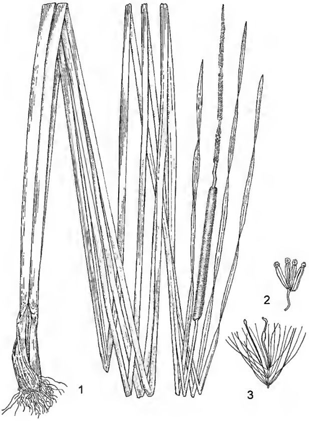
Production and international trade *Typha* as a fibre plant is only collected from the wild. No production statistics are available.

Properties The stems and leaves of *Typha domingensis* are tough and fibrous. The leaves are suitable for caulking, because they swell when wet. Paper made from *Typha* is fairly strong but difficult to bleach. The floss from the female part of the inflorescences has a high buoyancy and good insulating properties, both for heat and sound.

The rhizome contains starch and a toxic substance with purgative and emetic properties. Stems (moisture content 88%) from the Zambezian region contained per 100 g dry matter: energy 1253 kJ (299 kcal), protein 1.4 g, fat 0.5 g, carbohydrates 81.9 g, fibre 3.2 g, Ca 20 mg, P 30 mg and Fe 10 mg. The seeds contain a drying oil similar in quality to linseed oil. Aqueous extracts of *Typha domingensis* have shown phytotoxic properties, inhibiting the germination of lettuce and radish seeds and the growth of the water fern *Salvinia minima* Willd.

Adulterations and substitutes A range of *Cyperaceae* and *Pandanaceae* may be used for weaving. For wastewater treatment the most frequently used plant around the globe is common reed (*Phragmites australis* (Cav.) Trin. ex Steud.). Other *Typha* species and various *Cyperaceae* are also widely used.

Description Perennial, monoecious, glabrous herb with long, creeping rhizomes; stem erect, up to 5 m tall, unbranched, solid. Leaves in two rows, mostly basal and sub-basal; sheath with sloping shoulders, purple spotted within; blade linear, flat, up to 1.5 m × 8–13 mm, narrow at the base, obtuse at the apex. Inflorescence a cylindrical spike, with the male part superposed on the female part, the two parts separated by a 1–3 cm long bare stalk, flowers numerous and closely packed; bract at base of each part leaf-like, caducous; male part 10–34(–40) cm × 1–1.5 cm, flowering earlier than female part; female part 10–25(–34) cm × 1.5–2 cm, bright reddish brown, rachis densely covered by wart-like, short excrescences bearing one to several fertile or sterile flowers with a narrow bracteole widened at the top into a short, flat blade. Flowers unisexual; male flowers with 2–3 flattened, forked or slenderly lobed bracts surrounding the stamens, filaments white, connate, anthers basifixed; female flowers with a fusiform ovary borne on a thin stalk surrounded by a whorl of hairs at the base, style distinct, short and thin, stigma flattened, linear to spatulate; sterile female flowers similar to fertile ones but with undeveloped ovary. Fruit a very small follicle, falling off before dehiscence together with its stalk, 1-seeded. Seed striate.



Typha domingensis – 1, habit of flowering plant; 2, male flower; 3, female flower.
Source: PROSEA

Other botanical information *Typha* comprises (8–)15(–20) species, most of which are widely distributed throughout the temperate, subtropical and tropical zones of both hemispheres. The taxonomy is still not clear and identification of the taxonomical units often difficult. In tropical Africa 4 *Typha* species occur. *Typha angustifolia* L. is a species of temperate regions of Europe and America and has been recorded erroneously for Madagascar. *Typha elephantina* Roxb. is distributed in Asia, the Mediterranean, Senegal, the Sahel, Ethiopia and in oases in the Sahara. The leaves are used for making mats, clothes, ropes, windbreaks and shelters. Young roots and leaf-bases are eaten as a vegetable and plants are grazed by sheep, goats and cattle. In India it is planted to control erosion, the pollen is made into bread, and the rhizome is used for the treatment of ulcers, dysentery and gonorrhoea.

Growth and development *Typha* seeds readily germinate in open wet areas, but mortality is high and few seedlings reach the reproductive stage. The seedlings can survive when submerged in water as well as when emerged. Once the plant is established, within a year after germination, rhizome growth starts and becomes the main mechanism maintaining a stand. Buds in 2 rows on each side of the rhizome apex may develop into new rhizomes or shoots. *Typha* species are perennials, with their rhizome enabling them to survive periods of cold and drought. Individual shoots do not live longer than 1 year. The pollen is transported by wind. On windy days cross-pollination may occur, but on calm days self-pollination is more likely. Estimates of the number of seeds per inflorescence are up to c. 680,000 and the number of seeds per m^2 has been estimated at 17 million for *Typha domingensis*. The fruits are easily transported by wind, with the hairs serving as parachutes. Within minutes of contact with water the follicular tissues saturate and split open, and the seed is released. Seeds remain viable for a long period if conditions are unfavourable for germination.

Ecology *Typha domingensis* grows in marshy locations, in shallow pools and along the margins of often stagnant, fresh or brackish water, along irrigation channels and in rice fields. It is known to grow at a water depth of up to 2 m. In East Africa it is found from sea-level up to 1500(–2300) m altitude. At higher altitudes it is usually growing mixed with *Typha latifolia* L.

Typha species are often associated with disturbed, fertile environments. They grow on a variety of soil types, but are usually found on fine-textured organic muds and silts, which have a high nutrient content and water-retention capacity. They are considered moderately salt-tolerant, but growth is significantly reduced at salinities higher than 3–5 ppt (parts per thousand). Permanent salinities of 7 ppt or higher exceed the tolerance limit. The success in brackish environments seems to stem from their ability to grow rapidly when fresh water is available and to persist in a dormant state under saline conditions.

Typha species are often considered weeds. They are able to dominate vegetations, because their bulky rhizome and their tall, dense canopy give them a competitive advantage. The formation of monospecific stands is aided by a mat of dead material, which prevents the establishment of other species, but which also may prevent growth of *Typha* seedlings. *Typha* species readily colonize disturbed areas where water is available, and may block irrigation and drainage channels. They also increase water loss because of their high transpiration. In Australia *Typha domingensis* is considered a major aquatic weed. In tropical Africa the dense *Typha* swamps can harbour dormitories with hundred-thousands of red-billed quelea (*Quelea quelea*) and offer protection to malaria mosquito larvae.

Propagation and planting *Typha domingensis* is propagated by rhizome division or seed. The 1000-seed weight is 0.02–0.03 g. Seeds do not germinate in the dark.

Management Cultivation of *Typha* spp. is easy along the margins of natural or artificial pools. Where it is considered a weed, it may be controlled effectively by cutting or crushing below the water level or by spraying with glyphosate.

Yield *Typha domingensis* is highly productive and in Cuba the aerial biomass production has been estimated at 13–15 t dry matter per ha per year.

Handling after harvest The stems may be split before being woven. For pulping, the fibre can be chemically extracted from stems and leaves together by treatment with sodium hydroxide.

Genetic resources In view of its wide distribution and occurrence in disturbed habitats *Typha domingensis* is not threatened with genetic erosion. No germplasm collections or breeding programmes of *Typha* species are known to exist.

Prospects The importance of *Typha domingensis* as a source of weaving material will probably remain limited to local use. For the lowland tropics it has huge potential as a component of aquatic plant systems for the treatment of wastewater.

Major references Burkill, 2000; Morton, 1975; Napper, 1971b; Riedl, 2003; Vymazal, 2011.

Other references Abbiw, 1990; Abira, van Bruggen & Denny, 2005; Arenas & Scarpa, 2003; Boiteau, Boiteau & Allorge-Boiteau, 1999; Catarino, 2002; Decary, 1946; Haule et al., 2002; Hickley & Bailey, 1986; IPK, undated;

Lye, 1997b; Malaisse, 1997; Malaisse & Parent, 1985; Ozenda, 1977; Raponda-Walker & Sillans, 1961; Schatz, undated; Tabuti, Lye & Dhillion, 2003.

Sources of illustration Riedl, 2003.

Authors C.H. Bosch

Based on PROSEA 17: Fibre plants.

TYPHA LATIFOLIA L.

Protologue Sp. pl. 2: 971 (1753).

Family Typhaceae

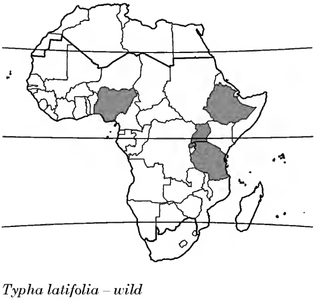
Chromosome number $2n = 30$

Vernacular names Bulrush, cattail, broad-leaved cattail, common cattail, reedmace, great reedmace (En). Massette à larges feuilles, quenouille à larges feuilles, roseau des étangs (Fr). Espadanha, murrão dos fogueteiros (Po).

Origin and geographic distribution *Typha latifolia* is widely distributed in temperate regions of the northern hemisphere, and at higher altitudes in Japan, North Africa and tropical Africa. Confusion of this species with other *Typha* species is common and few herbarium specimens have been collected. As a result it is hard to establish the exact distribution of *Typha latifolia* in tropical Africa.

Uses The leaves are used for making mats and baskets. In southern Africa the mature, silky female florets are used for stuffing cushions and pillows. The rhizomes are eaten as a famine food. American Indians used the leaves for thatching, and for making baskets, partitions and burial shrouds; a hot drink prepared from the powdered roots and leaf bases was taken to relieve stomachache.

In Tanzania and in many countries outside tropical Africa *Typha latifolia* is planted in basins for wastewater treatment. Use of, and research into improving such systems is well-documented, especially for eastern Europe. Plant material harvested from these basins is used as fuel, compost, cattle feed and thatch, and for making mats, hats, chair seats, paper and insulation material. In Estonia the plant material is cut into chips which are mixed with clay and made into building blocks, while fibrous material from the inflorescence axis is used to reinforce and avoid cracks in clay plaster.



Typha latifolia – wild

Typha spp. are also planted in Europe as ornamentals in ponds, and used as cut flowers.

Properties In the United States the crude fibre content of the leaves was found to be 66–77%, and the protein content 9%. Dry plant material has a high calorific value, which makes it valuable for fuel. Flavonoids and other phenolic compounds have been isolated from the plant, as well as several triterpenoids with a steroidal skeleton, such as typhasterol. The seed contains about 16% oil with a high linoleic acid content.

Botany Perennial, monoecious, glabrous herb with long, creeping rhizomes; stem erect, up to 3.5 m tall, unbranched, solid. Leaves in two rows, mostly basal and sub-basal; sheath with abruptly rounded to auriculate shoulders, sometimes purple spotted within; blade linear, flat, up to 200 cm × 1 cm, base narrow, apex obtuse. Inflorescence a cylindrical spike, with the male part superposed on the female part, the two parts contiguous, flowers numerous and closely packed; bract at base of each part leaf-like, caducous; male part 5–12 cm × 1.5–2.5 cm, flowering earlier than female part; female part 13–25 cm × 2.5–3.5(–4) cm, yellow-green, becoming sepia-brown or almost black, rachis densely covered by numerous fertile and sterile flowers without bracteole, sometimes constricted or interrupted, each interruption or constriction with a bract, interruption up to 3.5 cm long. Flowers unisexual; male flowers reduced to stamens, with linear bracts surrounding the stamens, filaments white, anthers basifixed; female flowers with a fusiform ovary borne on a thin stalk surrounded by a whorl of hairs at the base, style longer than the surrounding hairs, stigma broadly lanceolate; sterile female flowers as long as the hairs, pale speckled with red. Fruit a very small, elliptical follicle falling off before dehiscence together with its stalk, 1-seeded. Seed striate.

Typha comprises (8–)15(–20) species, most of which are widely distributed throughout the temperate, subtropical and tropical zones of both hemispheres. The taxonomy is still not clear and identification of the taxonomical units often difficult. In tropical Africa 4 *Typha* species occur. *Typha capensis* (Rohrb.) N.E.Br. (synonym: *Typha latifolia* subsp. *capensis* Rohrb.) is distributed from Rwanda, Kenya and Uganda through southern Africa to South Africa. The leaves are made into brooms and are used for weaving and thatching. Rhizome decoctions are taken to cure venereal diseases or during pregnancy to ensure easy delivery and to promote expulsion of the placenta. They are also taken against painful menstruation, diarrhoea, dysentery, as an aphrodisiac and to promote blood circulation. The pounded rhizome is eaten as a source of starch. The pollen is rich in protein and are eaten in pancakes.

Ecology *Typha latifolia* grows in marshy locations and along the margins of streams with fresh water. It is known to tolerate a water depth of up to 1 m. In Kenya and Uganda it is found above 1300 m altitude, in Ethiopia above 1600 m altitude. At the lower part of its altitudinal range it usually grows mixed with *Typha domingensis* (Pers.) Steud. *Typha latifolia* tolerates a pH of 4–10 and a salinity up to 0.5 ppt (parts per thousand). It further tolerates high levels of heavy metals, especially lead, zinc and copper.

Management *Typha latifolia* is propagated by rhizome division or seed. The seeds do not germinate in the dark. The plant is a host of the African sugarcane borer (*Eldana saccharina*), a pest of maize and sugarcane. Where it is considered a weed, it may be controlled effectively by cutting or crushing below the water level or by spraying with glyphosate. The annual biomass production of *Typha latifolia* is 5–90 t dry matter per ha depending on nutrient supply, site and climate.

Genetic resources and breeding In view of its wide distribution *Typha latifolia* seems not threatened with genetic erosion.

Prospects The importance of *Typha latifolia* fibres will probably remain limited to local use. For the highland tropics and for countries with temperate and cold climates it has huge potential as a component of aquatic plant systems for the treatment of wastewater.

Major references Burkill, 2000; Morton, 1975; Napper, 1971b; Vymazal, 2011; Watt & Breyer-Brandwijk, 1962.

Other references Brisson & Chazarenc, 2009; Burgoon, Reddy & DeBusk, 1989; CHCD, 1996; Fraser, Carty & Steer, 2004; Kamau, 2009; Maddison et al., 2009; Mazodze & Conlong, 2003; Mbuligwe, 2004; Neuwinger, 2000; van Wyk & Gericke, 2000.

Authors C.H. Bosch

URELYTRUM GIGANTEUM Pilg.

Protologue Bot. Jahrb. Syst. 34: 125 (1904).

Family Poaceae (Gramineae)

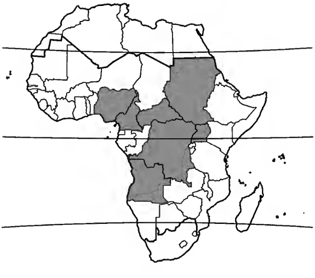
Synonyms *Rhytachne gigantea* Stapf (1908), *Urelytrum thyrsioides* Stapf. (1917).

Origin and geographic distribution *Urelytrum giganteum* is distributed from Nigeria eastward to Sudan and southward to DR Congo, Angola and Uganda.

Uses In Nigeria the stems are used for making mats. In the Central African Republic they are used as low-quality arrow-shafts. In Nigeria the grass serves as fodder.

Production and international trade *Urelytrum giganteum* is only used and traded locally.

Botany Perennial, robust, tufted grass; stems up to 4 m tall, up to 7 cm in diameter at the base. Leaves alternate; sheath tight, slightly rough, finely striate, glabrous; ligule 2–3 mm long, truncate, membranous; blade 30–100 cm × 10–25 mm, margin rough. Inflorescence terminal, composed of 20–50 pedunculate racemes, each 10–25 cm long and borne in whorls on a central rachis 15–30 cm long; rachis fragile at the nodes; internodes glabrous. Spikelets in pairs, 1 sessile and 1 pedicelled; sessile spikelet fertile, 2-flowered, lanceolate, 5–6 mm long, falling entire with accessory branch structures, callus oblong, 0.5 mm long, lower



Urelytrum giganteum – wild

glume elliptical, 5–6 mm long, smooth and glabrous except for the apical, spinulose keel, bluntly acute, upper glume ovate, chartaceous, keeled, 3-veined, lower floret male, with palea and oblong, hyaline lemma, upper floret bisexual, lemma lanceolate, hyaline, without keel, apex acute, palea hyaline, stamens 3, ovary glabrous, with free styles and 2 red stigmas; pedicelled spikelet sterile, elliptical, 4–5 mm long, persistent, glumes coriaceous, one glume with 7–15 mm long awn. Fruit an oblong caryopsis (grain).

Urelytrum comprises c. 10 species and is distributed in tropical Africa (including Madagascar) and South Africa. *Urelytrum digitatum* K.Schum. (synonym: *Urelytrum fasciculatum* C.E.Hubb.) is a perennial, tufted grass with stems up to 2 m tall, distributed from northern Nigeria, Cameroon and the Central African Republic southward through DR Congo, Uganda and Tanzania to Malawi, Zambia and Angola. On the Mambila Plateau in Nigeria the stems are used for making mats. *Urelytrum muricatum* C.E.Hubb. is a perennial, tufted grass with erect stems up to 2.5 m tall, distributed from Senegal eastward to northern Nigeria. In Bimbila (northern Ghana) the grass is lightly grazed, but probably only when better forage is lacking, because the stems are said to be bitter and are generally not taken. The stem is tough and has potential to be made into rope. In traditional medicine in Nigeria the bark is used against threatening miscarriage and bleeding. The bark has shown weak antibacterial activity against *Escherichia coli*, *Proteus mirabilis*, *Pseudomonas aeruginosa* and *Staphylococcus aureus*.

Ecology *Urelytrum giganteum* occurs up to 1300 m altitude in wet and swampy places in savanna regions.

Management *Urelytrum giganteum* is only collected from the wild.

Genetic resources and breeding *Urelytrum giganteum* is widespread and not intensively harvested. It is not in danger of genetic erosion.

Prospects *Urelytrum giganteum* is likely to remain of incidental, local use only.

Major references Burkill, 1994; Clayton, 1972; Clayton & Renvoize, 1982; Clayton et al., 2006–; Watson & Dallwitz, 1992.

Other references Adamu et al., 2005; Hubbard, 1949; Robyns, 1929; Stapf, 1917–1934; van der Zon, 1992.

Authors L.P.A. Oyen

URENA LOBATA L.

Protologue Sp. pl. 2: 692 (1753).

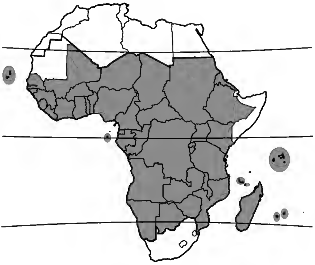
Family Malvaceae

Chromosome number $2n = 28, 56$

Vernacular names Congo jute, aramina, bur-mallow, cadillo, caesar weed, hibiscus bur, urena (En). Jute du Congo, jute de Madagascar, uréna, goune de Madagascar, herbe à paniers, grand cousin (Fr). Aguaxima, carrapicho do mato, carrapicho de lavadeira, carrapicho redondo, guaxima rósea, malvaísco, malva de embira, malva roxa, malva rósea (Po). Mpuruza, mchokochole jike, mtakawa jike (Sw).

Origin and geographic distribution The origin of *Urena lobata* is not certain, but it is probably of African or Asian origin. It is now widely distributed in a wild or naturalized state throughout the tropics and subtropics. In tropical Africa it occurs naturally from Cape Verde and Senegal eastward to Ethiopia and Eritrea, and southward across the continent to South Africa. It also occurs in the Indian Ocean islands. *Urena lobata* is grown as a commercial fibre crop in DR Congo, and for local use in Ghana, Nigeria and elsewhere in tropical Africa; commercial fibre production in Angola and Madagascar is mainly based on wild or naturalized plants.

Uses The bast fibre from *Urena lobata* is widely used traditionally for making cordage and coarse textiles, and industrially as a substitute for jute (*Corchorus* spp.), for instance to make sacks, carpets, cordage and upholstery. It is often used mixed with jute. In tropical Africa and elsewhere *Urena lobata* serves for making string, twines, ropes, fishing lines and nets, and nets for hunting, while the unprocessed



Urena lobata – wild and naturalized

bark is often used as tying material. In Ghana the stripped and plaited bark is used to bind loads. In Gabon it is used to affix leaves for thatching. In Malawi the stems are woven into walls of grain stores. In Madagascar the fibre is locally used in the manufacture of bags. The fibre of *Urena lobata* can be made into strong, bank-note quality paper and whole plants can be pulped as well.

Young shoots and leaves are eaten as a vegetable. In Malawi the flowers are eaten as a side-dish. The seeds contain oil and are mucilaginous and they are boiled in soups and with cereals. Cooked with rice they give it a pleasant slipperiness. Domestic animals eat the foliage. Some selections are grown as ornamental pot plants, flowering in winter.

The medicinal uses of *Urena lobata* are widespread and numerous, also in tropical Africa. It is considered expectorant and emollient. In Côte d'Ivoire a decoction of the plant is taken as oxytocic and against fever, in the Central African Republic against pneumonia. In Nigeria a preparation of the root is applied externally against rheumatism, a purpose for which it is also used e.g. in Vietnam. In Zanzibar and Indonesia a decoction of the root is taken against indigestion. In Madagascar a preparation of the root is applied to treat infected eyelids and against syphilis. Scrapings of the stem bark are put on wounds. In Gabon a macerate of the stem bark or root is prescribed against diarrhoea. In Madagascar a decoction of bark and root is given to children with enteritis or stomach pain. The leaves are widely used to induce labour or facilitate childbirth. In Côte d'Ivoire a preparation of the leaves with those of other plants is applied to treat menstrual problems. In Togo woman drink a decoction of the leaves and sometimes also from the stems and leaves of *Vernonia cinerea* (L.) Less. against infertility. In Benin a maceration of the leaves is taken against infectious diarrhoea. In Congo sap expressed from the leaves is given to women giving birth to their first child, and a leaf decoction is drunk against hypertension. In DR Congo powdered leaves with powdered clay in water is taken regularly as a treatment of asthma. In Uganda leaves are used against snake-bites and a leaf infusion is taken against diarrhoea. In Madagascar sap from the leaves is dripped onto wounds and a poultice of boiled leaves is applied to rheumatic inflammations, while a poultice of leaves and seeds is applied against problems of the gall bladder and other intestinal complaints. In Guinea water in which flowers are steeped is drunk as antiseptic. In Madagascar a decoction of the flowers is taken against respiratory problems.

Production and international trade As a traditional fibre crop *Urena lobata* is grown in many parts of the tropics, including tropical Africa. It was tested as a commercial crop, for instance in DR Congo, Nigeria and Sierra Leone. An extensive research programme was started in DR Congo in 1929, which led to large-scale production around the 1950s. After the 1970s production declined dramatically mainly due to competition from synthetic fibres and jute. Recent production and trade statistics of the fibre are not available, partly as they are often grouped together with those of jute. In the 1970s world production was estimated at 38,000 t per year, with about 70% produced in Brazil, 20% in DR Congo, and smaller amounts in Madagascar, Angola and Peru. Production in DR Congo in 1991 was estimated at 4300 t/year.

Properties Fresh stems of *Urena lobata* yield (3–)5–6(–7)% retted bast fibre. The fibre is fine, soft, flexible and lustrous, with a creamy white or pale yellow colour. It resembles jute more than other jute substitutes, such as kenaf (*Hibiscus cannabinus* L.) and roselle (*Hibiscus sabdariffa* L.). It can be spun on jute machinery without any change to the machines and without the operators needing experience with *Urena lobata*. The bast fibre cells are (0.8–)1.4–4.5(–5.9) mm long, with a diameter of (9–)12–19(–34) μm. Fibres investigated in Nigeria were on average 2.5 mm long and 21.6 μm wide, with a lumen width of 10.9 μm. Information on the fibre composition shows a wide variation in cellulose (63–87%) and lignin (7–12%) contents. Fibre strands extracted from wild plants are usually only about 1 m long, whereas fibre strands from cultivated plants has an average length of about 2 m. Rope made of *Urena lobata* fibre is considered less suitable for wet conditions, because of the lower wet strength and the fact that it deteriorates rapidly. The fibre quality can be improved by chemically joining them with acrylonitrile fibres. Kraft pulping experiments with *Urena lobata* bark and pith in South Africa gave pulp yields of 43–47%.

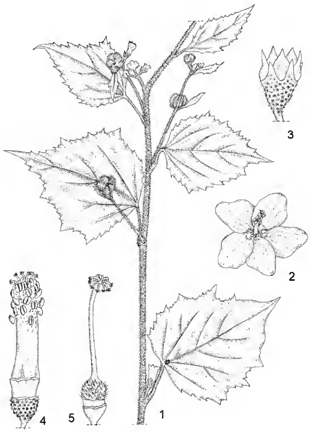
Per 100 g edible portion the raw leaves contain: water 81.8 g, energy 226 kJ (54 kcal), protein 3.2 g, fat 0.1 g, total carbohydrate (including fibre) 12.8 g, fibre 1.8 g, P 67 mg (Leung, Busson & Jardin, 1968). The composition of *Urena lobata* forage (moisture content 79.4%) in southern Nigeria was on a dry matter basis: crude protein 15.3%, ether extract 2.0%, crude fibre 17.6%, ash 6.0%, silica 3.9%, N-free extract 59.1%.

The seeds contain 7–18% oil, with linoleic acid, palmitic acid and oleic acid as major fatty acids, but also containing other poly-unsaturated fatty acids and the cyclopropenoid acids malvalic acid and sterculic acid. However, concentrations of the different compounds vary widely.

The numerous medicinal uses of *Urena lobata* are reflected by numerous biologically active compounds. The aerial parts contain the flavonoids quercetin, kaempferol, rutin, afzelin, astragalin, tiliroside, crenuloside and several kaempferol glycosides. They further contain the phenolic compounds syringic acid, glucosyringic acid, salicylic acid, protocatechuic acid, caffeic acid, diisobutyl phthalate, and also maleic acid and several long-chain fatty acids with an uneven number of C-atoms. A methanolic extract of *Urena lobata* roots has shown antibacterial activity against a range of microorganisms. Imperatorin, a furano-coumarin, has been isolated from the root.

Adulterations and substitutes As a fibre crop, *Urena lobata* has to compete mainly with jute, kenaf and roselle. It is as fine and supple as jute, but not as strong. It has about the same colour and lustre as kenaf and roselle, and is finer, but less strong and durable.

Description Highly variable annual or perennial shrub; weedy forms low, spreading and branching, 0.5–2.5 m tall, cultivated forms erect, poorly branched, up to 5 m tall; all aboveground parts more or less densely covered with minute stellate hairs, usually also with scattered, thin, purple-tinged simple hairs; taproot 20–25(–40) cm long, with lateral roots up to 2 m long. Leaves alternate, simple, extremely variable in size and shape; stipules linear to lanceolate or obovate, 2–4 mm long, acute, caducous; petiole up to 12 cm long; blade ranging from lanceolate, orbicular or broadly ovate to shallowly or deeply palmately 3–7-lobed, 1–12 cm × 0.5–13 cm, base cordate to cuneate, apex rounded to acuminate, margin serrate to crenate, both surfaces densely stellate hairy, palmately 3–9-veined from the base, with 1–3 linear nectaries near the base of the main veins beneath. Flowers solitary or in clusters of 2–3, axillary, in the upper part of the stem seemingly arranged in spikes or racemes because of the much reduced leaves, bisexual, 2–3 cm in diameter; pedicel 1–7 mm long; epicalyx campanulate to tubular, 7–8 mm × 5–6 mm, closely enveloping the calyx and at base adnate to it, at apex with 5 long-triangular teeth 3–5 mm × 1–3 mm; calyx tubular to campanulate, 5–6 mm × 1.5–2 mm, at apex with 5 ovate to acuminate lobes 4–6 mm × 1.5–2 mm, at about one-third from the base of the slightly prominent calyx veins a nectary or a thickening only is present; petals 5, obovate, 1–1.5(–2.5) cm long, rounded at the apex, pink with a purple base inside; stamens arranged into a staminal column 10–14 mm long, usually curved, anthers in upper half, purple; ovary superior, 5-carpelled, style in the centre of the staminal column, at the apex divided into 10 arms each 1 mm long, stigmas 10, capitate, papillose, dark purple. Fruit a depressed globose schizocarp 6–10 mm wide, composed of 5 trigonous, indehiscent, mericarps, covered with barbed bristles and a thick cover of stellate hairs; mericarps trigonous, 4–7 mm × 3–4 mm, 1-seeded. Seed reniform, 2–3.5 mm wide, minutely hairy to glabrous, brown. Seedling with epigeal germination; cotyledons petiolate, with



Urena lobata – 1, flowering and fruiting branch; 2, flower; 3, epicalyx and calyx; 4, staminal column with pistil; 5, pistil.
Source: PROSEA

suborbiculate to reniform blade, 10–18 mm × 9–16 mm; first leaves alternate, simple, first 2 with orbicular to oblong blade, from third leaf onwards blade lobed.

Other botanical information The taxonomy of *Urena* has not yet been settled. *Urena* has long been considered either a group of closely related species or a monotypic genus with *Urena lobata* as the only variable species, but at least 3 taxa in Australia are now accepted as distinct species. Like most recent African floras, this account follows the broad species approach. Within *Urena lobata* s.l. 2 distinct varieties are recognized for tropical Africa, based mainly on the shape of the leaves:

- var. *lobata*, characterized by unlobed to deeply palmately lobed leaves; the lobes usually narrowing from base to apex, but sometimes oblanceolate and widest near the apex; with narrow acute basal sinuses. It is pantropical and widely distributed in tropical Africa from sea-level up to 2100 m altitude. It is important as a source of fibre.
- var. *sinuata* (L.) Hochr. (synonym: *Urena sinuata* L.), with deeply 3–5-lobed leaves, only sometimes some scarcely or not lobed; especially the central lobes again lobed; the second-order lobes mostly broadest at the middle and broad and with more rounded sinuses leaving a large gap between the central and lateral lobes; occasionally with narrow leaves with a pair of lobes above the middle. It occurs at in Kenya, Tanzania and the Indian Ocean islands, and in Asia.

Urena is morphologically very close to *Pavonia*, which has mericarp bristles that are not barbed or with 3 hairy awns and leaves normally without nectaries. It is argued by several authors that the two genera should be merged.

Growth and development Cleaned and scarified seed may germinate within 5–8 days, but germination of seed in the husk may take place over a period of 2.5 months. The growth rate during the first month is slow, but subsequent growth is fast. The time to flowering depends on photoperiod, with flowering delayed by long photoperiods. Temperature effects on flowering have not been studied. The response to daylength and the length of the vegetative period vary with genotype; sometimes small differences in daylength, as occur near the equator, may affect flower initiation. In southern Ghana continuous flowering has been observed, while in a test in the same area in southern Ghana 12 days with a daylength shorter than 12 hours were required for flower initiation. In equatorial areas flowering occurs over a prolonged period and one node may simultaneously bear all stages from flower buds to ripe fruits. The flowers open early in the morning and wither about noon. They are capable of self-pollination, but the large intraspecific variation suggests a rather high percentage of cross-pollination. The nectaries are frequently visited by ants, aphids and various Hymenoptera. Dispersal is aided by the barbed spines on the fruits which stick to clothes and to the coats of animals.

Ecology For optimal growth and fibre production *Urena lobata* needs a hot and humid climate with ample sunlight and rainfall, and a deep, fertile, well-drained soil. It prefers an average temperature of 21–27°C, a relative humidity of 75–85%, and a monthly rainfall of 150–200 mm during the growing season. Under less favourable conditions it may grow as a short, branched, wiry shrublet. In tropical Africa *Urena lobata* occurs from sea-level up to 2100 m altitude in grassland, bushland, thickets, flood plains, river banks, roadsides and fallow land, less often in semi-deciduous forest. *Urena lobata* can be a troublesome weed, especially in pastures.

Propagation and planting *Urena lobata* is propagated with seed. The 1000-seed weight is 15–30 g and per ha about 60–80 kg unshelled seed is required, or 30–50 kg shelled seed. To obtain an even distribution of the seed, the bristly hooks should first be removed by rubbing with sand. Germination can be slow or uneven because of dormancy due to the impermeability of the seed-coat to water. It is considerably improved by shelling and scarification, for instance through removal of part of the seed-coat or treatment with concentrated sulphuric acid. Soaking in tepid water for 2 days also improves germination. *Urena lobata* is usually sown at the beginning of the rainy season in a well-prepared seedbed. Plants are closely spaced to prevent branching. Plant densities are usually around 300,000 plants/ha. In Sierra Leone spacings of 25 cm × 15 cm for fibre crops and 25 cm × 15 cm or 25 cm × 10 cm for seed crops have been recommended. Elsewhere a spacing of 5 cm × 5 cm has been recommended. Sowing may be done in rows (1–2 cm deep) or the seed may be broadcast.

Management Weeding of *Urena lobata* is necessary in the early growth stages and is usually done once or twice; the crop may be thinned at the same time. *Urena lobata* has a high nutrient demand. The nutrient uptake per hectare by a crop producing 40 t/ha green material has been estimated at 190 kg N, 24 kg P, 175 kg K and 148 kg Ca, of which 53%, 46%, 36% and 58%, respectively, is stored in the leaves. Therefore, returning the leaves to the soil helps to maintain soil fertility. In the wild state *Urena lobata* is a perennial, but it is usually grown as an annual crop. In some areas it is grown as a perennial, but rarely ratooned more than once. Because of the high nutrient uptake it is recommended that *Urena lobata* be grown in rotation.

Diseases and pests *Urena lobata* can be seriously damaged by several fungi that form stem lesions ('stem canker'). The most widespread of these fungi are *Botrytis cinerea* and *Macrophoma urenae*. Another disease is damping-off or seedling blight caused by *Fusarium* spp. In India *Urena lobata* is attacked by *Corynespora callicioidea*, causing scattered, yellowish-red, irregular lesions on the leaves, with a black centre that develops into a hole. The fungal diseases can be controlled by treating seed with fungicides and by crop rotation. *Urena lobata* is an alternate host for the okra mosaic virus.

Urena lobata is attacked by some serious pests of cotton (*Gossypium* spp.), kenaf, roselle and ramie (*Boehmeria nivea* (L.) Gaudich.), such as cotton stainers (*Dysdercus* spp.) and leaf rollers (*Sylepta* spp.). *Dysdercus superstitiosus* can strongly reduce the viability of *Urena lobata* seeds, but the fibre yield is unaffected. In Africa and Asia *Urena lobata* is attacked by spiny bollworms (*Earias* spp.). *Urena lobata* seems highly resistant to nematodes.

Harvesting To obtain the highest yield and the best quality of fibre *Urena lobata* should be harvested when the plants are in full bloom. If harvested earlier, the fibre is finer but shorter and the yield is lower; if harvested later, the fibre is coarser, less white and shiny, and retting is more difficult. The plants are cut at about 20 cm above the ground, because the stem base is highly lignified and does not ret properly.

Yield Fibre yields of 0.5–1.5 t/ha are normally obtained from *Urena lobata* in farmers' fields, while experimental yields of up to 3.6 t/ha have been recorded. Yields from wild stands are only about 300 kg/ha. In 1991 the average yield in DR Congo was reported to be 720 kg/ha. In India the cultivar JRU 415, spaced at 30 cm × 6 cm and fertilized with 60 kg N, 40 kg P and 60 kg K per ha, has yielded 2.85 t/ha.

Handling after harvest After harvest the plants are sometimes defoliated directly or after having been piled for 2–4 days to promote leaf shedding. Subsequently, the stems are tied in bundles with a diameter of 20–35 cm and retted in running or stagnant water for 7–20(–30) days, depending on water temperature and age of the stems. The bundles are suspended at least 10 cm below the water surface to prevent discolouration by sunlight, but above the bottom to prevent uneven retting or staining. The water should be clean and free of iron or other chemicals which can stain or change the colour of the fibre. After retting the fibre is stripped from the stem by hand, washed and dried in the sun. Sometimes the dry fibres are rubbed between the hands to increase lustre and suppleness and to remove any remaining extraneous matter. After retting a trained person can produce about 4 kg fibre per day. A raspador type of decorticator can also be used for fibre extraction. The fibres are graded according to quality, colour, length and strength, but grading systems vary among countries.

Genetic resources In view of its wide distribution, *Urena lobata* does not seem threatened by genetic erosion. In Madagascar harvesting of wild plants for fibre production is regulated by legislation to prevent overexploitation. Small germplasm collections are kept at the International Jute Organization, Dhaka, Bangladesh, and the USDA (United States Department of Agriculture) Southern Regional Plant Introduction Station, Griffin, Georgia, United States.

Breeding The variability within *Urena lobata* offers opportunities for selection. Cultivars with different growing period and fibre yield characteristics have been selected in various countries, such as 'JRU 415' in India. In West Africa 'ex Mokwa' from Niger State (Nigeria) is well-known selection.

Prospects *Urena lobata* yields fibre of good quality, comparable to jute, suitable for making sacks and paper, but it is a smaller plant, giving lower yields per hectare. In addition, jute is mainly grown in Bangladesh and India where labour costs are extremely low. On the other hand, *Urena lobata* is a well established crop in several parts of Africa and comparatively little research has been done on *Urena lobata* and the great variability of this species remains largely untapped. Therefore systematic collection and evaluation of the genetic diversity seems warranted as a first step to improve this crop. A systematic evaluation of the pharmacological properties also seems warranted.

Major references Baert & Raemaekers, 2001; Burkill, 1997; Dempsey, 1975; Escobin & Widodo, 2003; Harris, 1981; Harris & Bindi, 1983; Jernander, 1940; Kirby, 1963; Neuwinger, 2000; Verdcourt & Mwachala, 2009.

Other references Baerts & Lehmann, 2011; Eromosele, Eromosele & Funmilayo, 2008; Exell & Meeuse, 1961; Exell & Roessler, 1969; Hauman & Wouters, 1963; Hochreutiner, 1955; Jia et al., 2009a; Jia et al., 2009b; Keay, 1958d; Lejeune, 1953; Leung, Busson & Jardin, 1968; Mecha & Adegbola, 1980; Morelli et al., 2006; Mukherjee, 1969; Olotuah, 2006; Ong, 2001; Raponda-Walker & Sillans, 1961; Sosa & Carmelo, 2010; Vollesen, 1995a; Wang et al., 2009; Weiss, 1979.

Sources of illustration Ong, 2001.

Authors S. N'danikou, E.G. Achigan-Dako & L.P.A. Oyen

Based on PROSEA 17: Fibre plants.

URERA HYPSELODENDRON (Hochst. ex A.Rich.) Wedd.

Protologue Ann. Sci. Nat., Bot., sér. 3, 18: 203 (1852).

Family Urticaceae

Origin and geographic distribution *Urera hypselodendron* is distributed from Sudan and Ethiopia southward through eastern DR Congo, Rwanda, Burundi, Kenya, Uganda and Tanzania to Malawi, Zambia, Zimbabwe and Mozambique. It has been recorded from Guinea-Bissau, but is not otherwise known to occur in West Africa.

Uses The stem bark yields a fibre used for string and as sewing thread to stitch up gourds for holding milk. It is also used for making fishing nets and lines. The stem is used for basketry in Uganda. The leaf is eaten as a vegetable. The stem bark is used in traditional medicine for treatment of impetigo. Liquid from the stem is used as a tonic for pregnant women, and a decoction of the stem is mixed with milk and drunk by pregnant women with abdominal pain. A decoction of the leaf is taken as a purgative. In DR Congo the leaves are chewed as antivenin against snake bites, or the bite is rubbed with a maceration of the whole plant. A concoction of the leaf is given to sick chickens.

Properties The fibre obtained from the bark is black and strong. Leaves from Uganda had a crude protein content of 20.9 g per 100 g dry matter.

Botany Dioecious liana up to 25 m long or more; stem with numerous adventitious roots, sap abundant; bark reddish brown, glabrescent, without stinging hairs. Leaves alternate, simple; stipules fused for at least ⅔ of their length, triangular to lanceolate, up to 14 mm long, glabrous or hairy outside, dark brown, caducous; petiole up to 11 cm long, glabrous to hairy, with or without stinging hairs; blade ovate to obovate, 5–20 cm × 2.5–16 cm, base rounded to cordate, apex short-acuminate, rarely acute, margin toothed with more than 35 teeth on each side, upper surface glabrous or occasionally sparsely hairy, lower surface hairy to glabrescent, dark green, 3-veined from the base, with 3–7 pairs of lateral veins. Inflorescence an axillary, lax cyme up to 15 cm in diameter, with or without stinging hairs; male inflorescence usually larger than the female one, sessile or on peduncle up to 1 cm long; female inflorescence sessile or on peduncle up to 2 cm long. Flowers unisexual, 4-merous; male flowers in clusters up to 0.5 cm in diameter, pedicel 1–2.5 mm long, articulated, hairy, perianth c. 2 mm in diameter; female flowers densely clustered, sessile, perianth segments basally fused, unequal, ovary superior. Fruit an achene 1–1.5 mm long, compressed, slightly oblique, minutely granulate, brown, surrounded by the fleshy, orange-red perianth. Seeds 1 mm × 0.5 mm.

In Kenya *Urera hypselodendron* flowers in October–May and in August.

Urera comprises about 35 species and occurs in tropical Africa including Madagascar, tropical America and Hawaii.

Ecology In East Africa *Urera hypselodendron* occurs at 1000–3100 m altitude, in rainforest and bamboo forest, especially in clearings and near margins, sometimes on isolated trees left in farmland.

Management *Urera hypselodendron* is usually collected from the wild, but in Tanzania there are some local initiatives to domesticate it as a vegetable. It is also said to have been planted in DR Congo, near Lake Tanganyika. The 1000-seed weight is 0.13 g. The optimum temperature for germination is 25°C. To obtain the fibre in DR Congo, the bark is dried and crumpled well, and the fibre is taken out.

Genetic resources and breeding *Urera hypselodendron* is widely distributed and seems not threatened by genetic erosion.

Prospects *Urera hypselodendron* is a useful local source of fibre for cordage and fishing gear, and the stems are used for basketry. The plant also provides other useful products, such as edible leaves and traditional medicines. Detailed information on the fibre properties as well as the nutritional and pharmacological properties is lacking, making it difficult to assess the prospects for this species.

Major references Beentje, 1994b; Burkill, 2000; Friis, 1986; Friis, 1989c; Yamada, 1999.

Other references Chifundera, 1987; Hauman, 1948b; Kalanda & Bolamba, 1994; Kokwaro, 1993; Mwihomeke et al., 2000; Neuwinger, 2000; Rothman et al., 2006; Teketay & Granström, 1997; Vainio-Mattila, 2000; Wild & Mutebi, 1996.

Authors M. Brink

URERA RIGIDA (Benth.) Keay

Protologue Kew Bull. 1955: 141 (1955).

Family Urticaceae

Synonyms *Urera elliotii* Rendle (1916).

Origin and geographic distribution *Urera rigida* is distributed in West Africa, from Sierra Leone to Cameroon.

Uses The stem bark yields a fibre used for making fishing lines in Nigeria. In African traditional medicine a decoction of the plant is drunk as a diuretic. A decoction of the leaf is taken to treat neuralgia in Côte d'Ivoire, and for treatment of furuncles a leaf poultice is applied twice daily. Leaf sap is added to palm wine to be drunk for treatment of diarrhoea with blood. Leaf sap together with sap of *Costus afer* Ker Gawl. and water is taken against pain in the side, e.g. in case of pneumonia. Powdered leaves are added to rice as an aphrodisiac. In Côte d'Ivoire the plant is an ingredient of arrow poisons, whereas sap from the crushed inflorescence is taken as a poison antidote.

Properties The fibre obtained from the bark is black and strong. The stinging hairs cause pustules and blisters on the skin.

Botany Liana attached by adventitious roots; stem stout but rather soft, with colourless gum, stinging hairs present. Leaves alternate, simple, with stinging hairs; stipules present; petiole up to 13 cm long, with stinging hairs; blade broadly elliptical to suborbiculate, up to 24 cm × 16 cm, base rounded, apex acuminate, margin distinctly toothed, more or less rough above, lower surface short-hairy, 3-veined from the base. Inflorescence lax, much branched, with stinging hairs. Flowers unisexual, small, 4-merous; female flower with superior ovary. Fruit an achene, red, surrounded by the fleshy perianth.

In Benin *Urera rigida* flowers in September.

Urera comprises about 35 species and occurs in tropical Africa including Madagascar, tropical America and Hawaii. The taxonomy of the West African *Urera* species is incompletely known. The bark of *Urera longifolia* Wedd., a shrub up to 2 m tall endemic to Madagascar, also yields a strong fibre. It was formerly used for fishing lines, but has been replaced by nylon fibre.

Ecology *Urera rigida* occurs in dense semi-deciduous forest, periodically inundated locations and fallow land.

Genetic resources and breeding In view of its fairly wide distribution, *Urera rigida* does not seem in danger of genetic erosion.

Prospects *Urera rigida* is a useful local source of fibre for cordage and is used for treatment of various ailments in African traditional medicine. Detailed information on the fibre properties and pharmacological properties is lacking, however, making it difficult to assess the prospects for this species. A taxonomic revision of West African *Urera* species is long overdue.

Major references Akoègninou, van der Burg & van der Maesen, 2006; Burkill, 2000; Keay, 1958i; Neuwinger, 1996.

Other references Boiteau, Boiteau & Allorge-Boiteau, 1999; Bouquet & Debray, 1974; Hawthorne & Jongkind, 2006; Kerharo & Bouquet, 1950; Leandri, 1965; Neuwinger, 1998; Neuwinger, 2000.

Authors M. Brink

VANILLA AFRICANA Lindl.

Protologue Journ. Linn. Soc., Bot. 6: 137 (1862).

Family Orchidaceae

Synonyms *Vanilla crenulata* Rolfe (1896).

Origin and geographic distribution *Vanilla africana* is distributed from Guinea eastwards to DR Congo and is also recorded from Principe.

Uses The aerial roots of *Vanilla africana* are used as strings for a number of stringed instruments such as guitars in Ghana and Gabon and mandolins in DR Congo. In Côte d'Ivoire the heated leaves are pounded with a capsicum pepper and the sap is applied into the ear to cure inflammation. In Liberia boiled leaves are put between 2 mats on which a woman suffering from a painful menstruation has to lay face-down to get relief.

Botany A fleshy, herbaceous, perennial vine, climbing trees by means of long leaf-opposed adventitious roots. Stem long, cylindrical, simple or branched, succulent, dark green. Leaves alternate; petiole short; blade oblong-elliptical to linear-lanceolate, 8–17.5 cm × 1.5–6.5 cm, rounded at the base, apex acute to acuminate, margin entire, fleshy. Inflorescence a short axillary raceme, 2.5–8 cm long, (5–)12–40-flowered. Flower waxy, white, cream or pale green; sepals 2–3 cm long; 2 upper petals like sepals, lower petal wider and 3-lobed, marked pink to purple. Fruit a pendulous, narrowly cylindrical capsule.

The genus *Vanilla* is pantropical and comprises c. 100 species, most of which in tropical America. Recent work on the genus showed that inter-specific hybridization and possibly polyploidization played a role in its evolution. The taxonomy of the genus still needs research. *Vanilla grandifolia* Lindl. is known from Principe, Gabon and DR Congo. Its aerial roots are used in Gabon to make fishing nets.

Ecology *Vanilla africana* is found in primary and secondary forests, dense shrubby vegetation and in plantations at altitudes up to 900 m above sea-level.

Genetic resources and breeding *Vanilla africana* as well as all other species in the genus are placed in CITES Appendix II and as such the trade is controlled in order to avoid use that could be incompatible with survival of the species.

Prospects *Vanilla africana* does not have the potential to become an important fibre plant.

Major references Burkill, 1997; Raponda-Walker & Sillans, 1961; Szlachetko, Sawicka & Kras-Lapinska, 2004.

Other references Adjanohoun & Aké Assi, 1979; Bory et al., 2008; Geerinck, 1974; Szlachetko & Kowalkowska, 2007; Szlachetko & Olszewski, 1998.

Authors C.H. Bosch

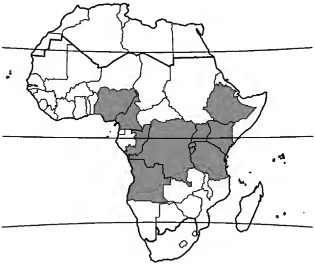
VERNONIA AURICULIFERA Hiern

Protologue Cat. Afr. Pl. 1: 539 (1898).

Family Asteraceae (Compositae)

Synonyms *Vernonia laurentii* De Wild. (1915), *Vernonia uniflora* Hutch. & Dalziel (1931), *Gymnanthemum auriculiferum* (Hiern) Isawumi (2008).

Origin and geographic distribution *Vernonia auriculifera* occurs from Nigeria and Cameroon eastward to Ethiopia and southward to Angola and Tanzania.



Vernonia auriculifera – wild

Uses In Kenya Maasai use the stems and leaves in hut-construction and Kipsigis use these materials to make platforms in hut-roofs for grain storage. In Kenya the leaves are also used for wrapping plant drugs to be roasted and used as a poultice. In Uganda the leaves are used as a substitute for toilet paper.

The stems are burnt as fuel. In Rwanda and DR Congo the leaves and young twigs are eaten by domestic animals. The stems, leaves and flowers yield a dye: green coloured without mordant or with alum, and golden coloured with chrome. *Vernonia auriculifera* is left to grow or sometimes planted as a fallow plant to improve the soil or as a shade-providing nurse tree. In Ethiopia it is said that when the plant flowers it is time to sow millet.

In Kenya *Vernonia auriculifera* is used in traditional medicine in similar manners as *Vernonia amygdalina* Delile. Meinit people in Ethiopia apply the root topically against toothache. In Tanzania the root soaked in water is a purgative for children. In DR Congo a drop of juice from the crushed stem bark is instilled in each nostril to treat headache. Leaf preparations are used in various countries against dysentery and stomachache. In Uganda an infusion of the leaves is taken against worms and a leaf decoction is drunk for the treatment of malaria. Leaf extracts are drunk as oxytocic and abortifacient and against post-partum pains. Pulverized leaves are used against impetigo, and in Congo the dried and pounded leaves are applied on wounds. In Cameroon the leaf juice is used as eye drops for the treatment of cataract.

Production and international trade *Vernonia auriculifera* is only used locally.

Properties 8-Desacylvernodalol was isolated from the methanolic extract of fresh leaves of *Vernonia auriculifera*. The compound exhibited phytotoxic activity against seedlings of lettuce. Chloroform, ethyl acetate and methanol leaf extracts have shown mild antiplasmodial activity against *Plasmodium falciparum* isolate K39. In a test in Uganda, the dichloromethane extract of the root has shown slight antitrypanosomal activity. In Kenya, extracts of *Vernonia auriculifera* were found to be toxic, possibly due to hydroperoxides of unsaturated fatty acid methyl esters.

Botany Small tree, shrub or woody herb up to 9 m tall; stems branching from low down, at first brownish hairy; bark smooth, grey. Leaves petiolate or especially the upper ones sessile; petiole up to 7.5 cm long, often auriculate; blade elliptical or narrowly obovate to ovate, 10–45 cm × 3–23 cm, attenuate towards the rounded, truncate or cordate base, apex acute or shortly acuminate, margin toothed, upper surface dull green, thinly fine-hairy mainly on veins and glabrescent, lower surface whitish with often floccose tomentum. Inflorescence composed of numerous heads in very large terminal compound thyrsoid cymes, the whole inflorescence up to 150 cm in diameter; involucre narrowly cylindrical, 4–6 mm long; phyllaries in 6–7 rows, appressed, green, especially the inner rows often tinged purplish in the upper part, broadly ovate to ovate or elliptical, apex obtuse to rounded, minutely apiculate, the inner rows elliptical, 4–6 mm long, usually acute, the innermost eventually falling. Florets 1 per head; corolla 6.5–9 mm long, scented, mauve, lilac or purplish, fading to white with age, lobes 2–3 mm long, glabrous except the throat; anthers distally with linear or lanceolate appendage; style branches long-tapering with stigmatic papillae above near the base. Fruit an achene 3–4 mm long, 8–10-ribbed, shortly ascending-pubescent to almost glabrescent except at the apex; outer pappus of narrow scales up to 1.5 mm long, inner pappus white, 5–8 mm long.

Vernonia comprises about 500 species in the Old World tropics and the Americas. It is here retained in a broad sense, but major changes in the circumscription are underway in the Old World species; *Vernonia auriculifera* has recently been transferred to *Gymnanthemum*, but the old name is retained in the present article because not the whole genus has been revised yet.

Ecology *Vernonia auriculifera* occurs at 750–3000 m altitude in open grassland or at the margin of forest in mountainous areas. In south-western Uganda it is characteristic of the shrub layer in old secondary vegetation changing into forest, e.g. in abandoned banana plantations. It is locally abundant in wet montane forest, but also beside streams or lakes, e.g. in Uganda.

Management *Vernonia auriculifera* may be propagated by seed or wildlings. Plants are fast-growing and yield fuelwood in 3–5 years.

Genetic resources and breeding *Vernonia auriculifera* has a wide area of distribution and is locally common. There are no indications that it is in danger of genetic erosion.

Prospects The medicinal uses of *Vernonia auriculifera* warrant further pharmacological research. Its role as a fallow and fuel crop deserves more attention. As a fibre plant it is likely to remain of local use only.

Major references Adams, 1963; Beentje, 2000; Hindmarsh, 1982; Katende, Birnie & Tengnäs, 1995; Neuwinger, 2000.

Other references Chifundera, 2001; Freiburghaus et al., 1996; Giday, Asfaw & Woldu, 2009; Hamill et al., 2000; Isawumi, 2008; Kanzila, 1994; Keriko et al., 1995a; Keriko et al., 1995b; Kokwaro, 1993; Muregi et al., 2003.

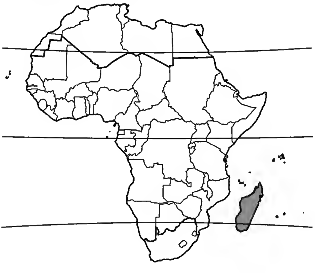
Authors L.P.A. Oyen

VIGUIERANTHUS GLABER Villiers

Protologue Du Puy, Legum. Madagascar: 276 (2002).

Family Mimosaceae (Leguminosae - Mimosoideae)

Origin and geographic distribution *Vigui-*



Viguieranthus glaber – wild

eranthus glaber is endemic to the northern and north-western parts of Madagascar.

Uses The stems of *Viguieranthus glaber* are used for making brooms.

Properties The wood has a bad smell.

Botany Much branched shrub up to 2 m tall or small tree up to 12 m tall; bark splitting, yellowish grey; young branches grey-brown to grey, thinly pubescent, with red glandular hairs. Leaves alternate, bipinnately compound with a single pair of pinnae; stipules leathery, persistent; petiole 2–13 mm long, with raised, winged margins and gland at apex on upper side; pinna axis 1–3.5 cm long, with winged margins; leaflets 7–23 per pinna, alternate to almost opposite, sessile, rhombic to obovate, up to 16 mm × 7 mm, asymmetrical at base, obtuse to rounded at apex, glabrous. Inflorescence an axillary head, solitary or in clusters, many-flowered; peduncle 2–5 cm long. Flowers bisexual, regular, 4-merous; calyx cup-shaped, c. 1 mm long, leathery; petals fused at base, 4.5–5 mm long, white; stamens numerous, c. 10 mm long, fused over 2–3 mm; ovary superior, stalked, 1-celled, style up to 16 mm long, slender. Fruit a linear-oblanceolate pod up to 13.5 cm × 1 cm, with long stipe, short soft-hairy, black, splitting into 2 valves. Seeds rhombic to oblong, up to 11 mm × 6 mm, black.

Viguieranthus comprises about 23 species, 18 of them endemic to Madagascar, 1 occurring in both the Comoros and Madagascar and the other 5 species restricted to tropical Asia.

Ecology *Viguieranthus glaber* is found in dry thickets and woodland from sea-level up to 500 m altitude.

Genetic resources and breeding In view of the fairly large distribution area of *Viguieranthus glaber* in Madagascar, it is not liable to genetic erosion.

Prospects *Viguieranthus glaber* will remain of local importance for making brooms.

Major references Boiteau, Boiteau & Allorge-Boiteau, 1999; du Puy et al., 2002.

Other references ILDIS, 2005; Lewis et al., 2005.

Authors C.H. Bosch

WISSADULA ROSTRATA (Schumach. & Thonn.) Planchon ex Hook.f.

Protologue Hook., Niger Fl.: 229 (1849).

Family Malvaceae

Synonyms *Sida rostrata* Schumach. & Thonn. (1827), *Wissadula amplissima* (L.) R.E.Fr. var. *rostrata* (Schumach. & Thonn.) R.E.Fr. (1908), *Wissadula hernandioides* (L'Hér.) Garcke var. *rostrata* (Schumach. & Thonn.) R.E.Fr. (1914).

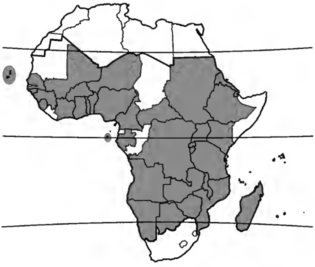
Origin and geographic distribution *Wissadula rostrata* occurs throughout tropical Africa, from Cape Verde and Senegal eastward to Eritrea and southward to South Africa and in Madagascar, but in Mauritius and Réunion it is only known from old collections. It also occurs in Yemen.

Uses In Cameroon the bast fibre is used for making rope and fishing nets. In Sudan a long and strong fibre is extracted from the bark and the plant has been cultivated for this purpose. Stems or twigs are used as toothbrush and made into brooms. In Sudan, and to a lesser extent elsewhere, the plants are browsed by domestic animals.

In traditional medicine in Côte d'Ivoire a laxative or purgative prepared from the plant is given to treat jaundice and to heal bleeding sores. Ashanti people in Ghana apply a compress prepared of the leaves to treat spider bites and stings by bees and wasps. In Togo a maceration of the leaves is drunk to treat bloody diarrhoea. In Benin a decoction of the plant is drunk or applied as a wash against oedema. In the Central African Republic, a compress of the leaves with root scrapings of *Morinda lucida* Benth. is applied to treat craw-craw. In Tanzania a medicine against stomach problems is made from the plant.

Production and international trade *Wissadula rostrata* is only used and traded locally.

Properties Fibre cells in fibre from Nigeria were on average 3.2 mm long and 26.9 µm wide, with a lumen width of 6.8 µm. The high Runkel ratio (2.95) indicates that the fibre is



Wissadula rostrata – wild

less suitable for newsprint-paper production. The fibre of the very closely related *Wissadula periplocifolia* (L.) K.Presl ex Thwaites (synonym: *Wissadula rostrata* var. *zeylanica* Masters) from Asia is similar in quality to that of kenaf (*Hibiscus cannabinus* L.).

Several extracts of the plant have shown dose-dependent anti-inflammatory effects against carrageenan-induced oedema in test animals.

Botany Erect, shrubby herb up to 2.5 m tall, branched from the base; stems with white stellate hairs and simple hairs, glabrescent and ultimately covered with a thin greyish bark. Leaves variable within a plant, lower ones petiolate, towards the top becoming nearly sessile and sometimes clasping the stem; stipules c. 6 mm long, bristly; petiole up to 18 cm long, stellate hairy; blade 2.5–19 cm × 1.5–14.5 cm, base truncate to cordate, apex long-caudate, margin entire or slightly toothed, lower surface whitish grey and densely velvety hairy, with scattered stellate hairs, upper surface more sparsely minutely stellate hairy to glabrous and rather dark green. Inflorescence a lax, terminal panicle ultimately up to 50 cm long. Flowers bisexual; pedicel 1–3.5 cm long (elongating to 6–7 cm in fruit), articulated towards the apex, puberulous to stellate-floccose; epicalyx absent; calyx 3–5 mm long, 5-lobed, stellate-pubescent, lobes triangular and acute; petals 5, 4–7 mm long, yellow to orange; staminal tube glabrous, free parts of filaments numerous; ovary superior, consisting of 5 free carpels, carpels 2-celled. Fruit of 5 mericarps, angular obconic; mericarps 7–11 mm × c. 3 mm, beaked, pubescent, glabrescent, opening with 2 apical valves, 1–3-seeded. Seed globose to kidney-shaped, c. 3 mm long, black, hairy.

Wissadula comprises c. 40 species, most of them in the Americas, but 3 in the Old World. The African species *Wissadula rostrata* has sometimes been recognized at specific rank and sometimes in varietal rank within *Wissadula amplissima* or *Wissadula hernandioides*, both from the Americas. Specimens have also often been identified as *Wissadula periplocifolia* sensu Cufod. In a recent revision it was noted that *Wissadula rostrata* has greater affinity with the South American *Wissadula parviflora* (A.St.-Hil.) R.E.Fr., but that it merits recognition as a separate species.

Ecology *Wissadula rostrata* occurs from sea-level up to 1900 m altitude in grassland, bushland, thicket, woodland, forest and fallow land. It usually occurs in light shade on rocky and loamy soils.

Management In Cameroon the stem is retted in water to obtain the fibre.

Genetic resources and breeding As *Wissadula rostrata* has a very wide distribution and occurs in a wide range of habitats, including disturbed ones, it is not in danger of genetic erosion.

Prospects The quality of the fibre and the wide variation within *Wissadula rostrata* and its wide adaptability warrant selection of types with a high potential production of high-quality fibre and research into its management as a crop.

Major references Burkill, 1997; Exell & Meeuse, 1961; Fryxell, 2010; Keay, 1958d; Verdcourt & Mwachala, 2009.

Other references Adjanohoun et al., 1989; Akoègninou, van der Burg & van der Maesen, 2006; Hauman & Wouters, 1963; Marais & Friedmann, 1987; Medina, 1959; Mensah, Donkor & Fleischer, 2011; Neuwinger, 2000; Olotuah, 2006; Portères, 1974; Vollesen, 1995a.

Authors L.P.A. Oyen

XEROPHYTA SPEKEI Baker

Protologue Journ. Bot. 13: 234 (1875).

Family Velloziaceae

Synonyms *Vellozia spekei* (Baker) Jackson (1895).

Origin and geographic distribution *Xerophyta spekei* is distributed in Kenya, Tanzania, Zambia, Zimbabwe and Mozambique, and possibly also in Ethiopia.

Uses The stem is pounded and made into very strong brooms and paintbrushes in Kenya. Unspecified plant parts are used for cleaning metal pans and utensils. In traditional medicine the leaf is used in case of stiffness of the neck or other body parts; a piece of cloth is put on the aching part, and the area is rubbed with the warmed leaf.

Botany Shrub up to 2(–5) m tall, with much-branched stems covered with persistent leaf-sheaths; stem up to 13 cm in diameter; branches subcylindrical, 6–12 mm thick. Leaves clustered at the end of stem or branches; sheaths densely overlapping, convex, keeled, with the midvein enlarged into a broad projection, shiny dark brown at the base, densely covered with white stiff hairs towards the apex; blade linear to filiform-attenuate, 5–35(–70) cm × 2–12 mm, leathery, glabrescent above, densely covered with white hairs beneath, somewhat scabrid with stiff hairs towards the apex, along the margin and along the midvein below, parallel-veined. Flowers 1–4 together in leaf axils at stem apex, on a peduncle 2–8 cm long with widely spaced glandular hairs, bisexual, regular, 3-merous; tepals in 2 series of 3, petal-like, linear-lanceolate, 20–35(–50) mm × 5–8 mm, white to pale blue, lilac or mauve, glandular at base; stamens 6, filaments almost completely united with tepals, anthers 13(–20) mm long; ovary inferior, ellipsoid, 0.5–1 cm long, densely covered with glands. Fruit a subglobose capsule up to 15 mm in diameter, many-seeded.

In Kenya *Xerophyta spekei* flowers in March–May and September–December.

Xerophyta comprises about 30 species, distributed in mainland Africa, Madagascar and southern Arabia. The stem of *Xerophyta squarrosa* Baker, an herb up to 1.5 m tall distributed in Angola, Namibia and South Africa, is used for brushing together grain on grinding stones. The leaves of several *Xerophyta* species endemic to Madagascar are used like those of *Xerophyta spekei* for rubbing pans and kitchen utensils. These species include *Xerophyta dasyliroides* Baker, a shrub up to 2 m tall, *Xerophyta eglandulosa* H.Perrier, a shrub up to 60 cm tall, and *Xerophyta pinifolia* Lam., a shrub up to 60 cm tall. The leaves of *Xerophyta dasyliroides*, known as 'oignon des pierres' or 'poireau des pierres', are also fed to chickens, whereas dried leaves have been used for igniting fire.

Ecology *Xerophyta spekei* occurs on rock outcrops, at 300–1900 m altitude.

Genetic resources and breeding *Xerophyta spekei* has a fairly wide distribution and there are no indications that it is threatened by genetic erosion.

Prospects The importance of *Xerophyta spekei* is unlikely to increase beyond its present use of locally supplying material for brooms and other cleaning materials.

Major references Beentje, 1994b; Kokwaro, 1993; Lye & Edwards, 1997; Medley & Kalibo, 2007; Smith & Ayensu, 1975.

Other references Boiteau, Boiteau & Allorge-Boiteau, 1999; da Silva, Izidine & Amude, 2004; Hyde & Wursten, 2009c; Neuwinger, 2000; Perrier de la Bâthie, 1950; Phillipson, 2004; SEPASAL, 2009g; Sölch, 1969.

Authors M. Brink

Fibres with other primary use

List of species in other commodity groups (parenthesis), which are used for their fibres. Synonyms are given in the indented lines (18 November 2011).
The names listed here have not been repeated in the Index of scientific plant names (p. 584).

- *Abelmoschus caillei* (vegetables)
  - *Hibiscus manihot* var. *caillei*
- *Abelmoschus esculentus* (vegetables)
  - *Hibiscus esculentus*
- *Abelmoschus moschatus* (essential oils and exudates)
  - *Hibiscus abelmoschus*
- *Abrus fruticulosus* (medicinal plants)
  - *Abrus pulchellus*
  - *Abrus schimperi*
- *Abrus precatorius* (medicinal plants)
- *Abutilon guineense* (medicinal plants)
- *Acacia ataxacantha* (auxiliary plants)
- *Acacia bussei* (fuel plants)
- *Acacia ehrenbergiana* (forages)
  - *Acacia flava*
- *Acacia erythrocalyx* (fuel plants)
- *Acacia farnesiana* (essential oils and exudates)
- *Acacia fleckii* (forages)
  - *Acacia cinerea*
- *Acacia hebeclada* (medicinal plants)
- *Acacia hockii* (fuel plants)
- *Acacia kirkii* (fuel plants)
- *Acacia laeta* (fuel plants)
- *Acacia mearnsii* (dyes and tannins)
  - *Racosperma mearnsii*
- *Acacia mellifera* (fuel plants)
- *Acacia natalitia* (stimulants)
  - *Acacia karroo*
- *Acacia nilotica* (dyes and tannins)
  - *Acacia adansonii*
  - *Acacia arabica*
  - *Acacia scorpioides*
  - *Acacia subulata*
- *Acacia oerfota* (fuel plants)
  - *Acacia nubica*
- *Acacia polyacantha* (essential oils and exudates)
  - *Acacia campylacantha*
- *Acacia reficiens* (medicinal plants)
- *Acacia senegal* (essential oils and exudates)
  - *Acacia rupestris*
  - *Mimosa senegal*
  - *Senegalia senegal*
- *Acacia seyal* (essential oils and exudates)
- *Acacia tortilis* (forages)
  - *Acacia raddiana*
  - *Acacia spirocarpa*
- *Acalypha bipartita* (vegetables)
  - *Ricinocarpus bipartitus*
- *Acalypha ornata* (medicinal plants)
- *Acalypha spachiana* (medicinal plants)
- *Acrocarpus fraxinifolius* (timbers)
- *Acrostichum aureum* (medicinal plants)
- *Adansonia digitata* (vegetables)
- *Adansonia grandidieri* (vegetable oils)
- *Adansonia rubrostipa* (vegetable oils)
  - *Adansonia fony*
- *Adansonia za* (vegetable oils)
  - *Adansonia alba*
  - *Adansonia bozy*
- *Adenia cissampeloides* (medicinal plants)
  - *Adenia gracilis*
  - *Adenia guineensis*
  - *Adenia gummifera*
- *Adenia lobata* (medicinal plants)
  - *Adenia mannii*
  - *Adenia rumicifolia*
  - *Adenia schweinfurthii*
- *Adenia racemosa* (medicinal plants)
- *Aerangis biloba* (ornamentals)
- *Aerva javanica* (medicinal plants)
  - *Aerva persica*
- *Aerva lanata* (medicinal plants)
- *Aeschynomene afraspera* (fuel plants)
  - *Aeschynomene aspera*
- *Aeschynomene fulgida* (medicinal plants)
  - *Aeschynomene arbuscula*
- *Aframomum angustifolium* (medicinal plants)
  - *Aframomum baumannii*
  - *Aframomum sanguineum*
- *Aframomum sceptrum* (spices and condiments)
  - *Aframomum masuianum*
- *Agave americana* (medicinal plants)
- *Agelaea paradoxa* (medicinal plants)
  - *Castanola paradoxa*
- *Agelaea pentagyna* (medicinal plants)
  - *Agelaea dewevrei*
  - *Agelaea heterophylla*
  - *Agelaea lamarckii*
  - *Agelaea mildbraedii*
  - *Agelaea nitida*
  - *Agelaea obliqua*

  - *Agelaea pilosa*
  - *Agelaea trifolia*
- *Alafia barteri* (medicinal plants)
- *Alafia fuscata* (medicinal plants)
- *Alafia pauciflora* (medicinal plants)
- *Alafia thouarsii* (medicinal plants)
- *Albizia bernieri* (timbers)
- *Albizia chevalieri* (medicinal plants)
- *Albizia lebbeck* (auxiliary plants)
- *Albizia polyphylla* (timbers)
- *Alchornea cordifolia* (medicinal plants)
- *Alchornea floribunda* (medicinal plants)
- *Alchornea hirtella* (medicinal plants)
- *Alchornea laxiflora* (medicinal plants)
- *Aleurites moluccanus* (vegetable oils)
- *Alhagi maurorum* (forages)
- *Allanblackia floribunda* (vegetable oils)
- *Allanblackia parviflora* (vegetable oils)
- *Allophylus africanus* (medicinal plants)
  - *Allophylus subcoriaceus*
- *Alpinia zerumbet* (essential oils and exudates)
  - *Alpinia speciosa*
- *Alysicarpus vaginalis* (forages)
- *Amaranthus caudatus* (cereals and pulses)
- *Ananas comosus* (fruits)
  - *Ananas sativus*
- *Ancylobotrys amoena* (essential oils and exudates)
  - *Landolphia amoena*
  - *Landolphia petersiana*
- *Ancylobotrys petersiana* (fruits)
- *Ancylobotrys scandens* (essential oils and exudates)
  - *Landolphia scandens*
- *Andropogon canaliculatus* (forages)
- *Andropogon chinensis* (forages)
  - *Andropogon ascinodis*
- *Andropogon fastigiatus* (forages)
  - *Diectomis fastigiata*
- *Andropogon gayanus* (forages)
- *Andropogon schirensis* (forages)
  - *Andropogon dummeri*
- *Andropogon tectorum* (forages)
- *Androsiphonia adenostegia* (medicinal plants)
- *Annickia affinis* (timbers)
  - *Enantia affinis*
- *Annickia chlorantha* (timbers)
  - *Enantia chlorantha*
- *Annickia polycarpa* (timbers)
  - *Enantia polycarpa*
- *Annona glabra* (fruits)
  - *Annona palustris*
- *Annona senegalensis* (fruits)
  - *Annona arenaria*
  - *Annona chrysophylla*
- *Anogeissus leiocarpa* (dyes and tannins)
  - *Anogeissus schimperi*
- *Ansellia africana* (ornamentals)
- *Anthocleista procera* (medicinal plants)
- *Anthonotha macrophylla* (timbers)
  - *Macrolobium macrophyllum*
- *Antiaris toxicaria* (timbers)
  - *Antiaris humbertii*
  - *Antiaris madagascariensis*
- *Arachis hypogaea* (cereals and pulses, vegetable oils)
- *Arenga pinnata* (carbohydrates)
- *Aristida adscensionis* (forages)
- *Aristida funiculata* (forages)
- *Aristida mutabilis* (forages)
- *Aristida sieberiana* (forages)
  - *Aristida pallida*
- *Arthraxon hispidus* (forages)
  - *Arthraxon micans*
  - *Arthraxon quartinianus*
- *Artocarpus altilis* (fruits)
  - *Artocarpus communis*
  - *Artocarpus incisus*
- *Artocarpus heterophyllus* (fruits)
- *Arundinella nepalensis* (forages)
- *Arundo donax* (auxiliary plants)
- *Asclepias curassavica* (ornamentals)
- *Asparagus africanus* (vegetables)
- *Asparagus buchananii* (medicinal plants)
- *Asparagus flagellaris* (vegetables)
  - *Asparagopsis flagellaris*
  - *Asparagus pauli-guilelmi*
- *Asplenium africanum* (ornamentals)
- *Athrixia phylicoides* (stimulants)
- *Aucoumea klaineana* (timbers)
- *Avena sativa* (cereals and pulses)
- *Azadirachta indica* (auxiliary plants)
- *Baissea leonensis* (medicinal plants)
- *Baissea multiflora* (medicinal plants)
  - *Baissea laxiflora*
- *Balanites aegyptiaca* (fruits)
- *Bambusa bambos* (timbers)
  - *Bambusa arundinacea*
- *Bambusa vulgaris* (timbers)
- *Baphia abyssinica* (fuel plants)
- *Baphia massaiensis* (dyes and tannins)
  - *Baphia obovata*
- *Baphia nitida* (dyes and tannins)
- *Barringtonia racemosa* (dyes and tannins)
- *Bauhinia kalantha* (medicinal plants)
- *Bauhinia madagascariensis* (timbers)
- *Bauhinia morondavensis* (timbers)
- *Bauhinia petersiana* (cereals and pulses)
  - *Bauhinia macrantha*
- *Bauhinia rufescens* (ornamentals)
- *Bauhinia tomentosa* (ornamentals)

Bauhinia urbaniana (medicinal plants)
Bauhinia variegata (ornamentals)
Beccariophoenix madagascariensis (carbohydrates)
Bergia suffruticosa (forages)
Bidens magnifolia (medicinal plants)
Bidens pilosa (vegetables)
  Bidens leucantha
Bismarckia nobilis (carbohydrates)
  Medemia nobilis
Bixa orellana (dyes and tannins)
Blepharispermum fruticosum (forages)
  Blepharispermum lanceolatum
Blighia welwitschii (timbers)
Bobgunnia madagascariensis (timbers)
  Swartzia madagascariensis
Borassus aethiopum (fruits)
Borassus flabellifer (carbohydrates)
Bothriochloa insculpta (forages)
Brachystegia boehmii (ornamentals)
  Brachystegia woodiana
Brachystegia eurycoma (timbers)
Brachystegia laurentii (timbers)
Brachystegia spiciformis (timbers)
Brachystegia utilis (fuel plants)
Breonadia salicina (timbers)
  Adina microcephala
  Breonadia microcephala
Breynia disticha (ornamentals)
  Breynia nivosa
  Phyllanthus nivosus
Bridelia atroviridis (medicinal plants)
Bridelia ferruginea (fuel plants)
Bridelia taitensis (ornamentals)
Brugmansia suaveolens (ornamentals)
  Datura suaveolens
Bruguiera gymnorhiza (dyes and tannins)
Buddleja madagascariensis (medicinal plants)
Burkea africana (timbers)
Butea monosperma (ornamentals)
  Butea frondosa
Cadaba farinosa (medicinal plants)
Cajanus cajan (cereals and pulses)
  Cajanus indicus
Cajanus kerstingii (cereals and pulses)
Calligonum polygonoides (auxiliary plants)
  Calligonum comosum
Calotropis gigantea (medicinal plants)
Calotropis procera (medicinal plants)
Calycobolus africanus (medicinal plants)
Calycobolus heudelotii (medicinal plants)
Cananga odorata (essential oils and exudates)
Canavalia ensiformis (vegetables)
Canavalia rosea (auxiliary plants)
  Canavalia maritima
  Canavalia obtusifolia
Canna indica (ornamentals)
  Canna bidentata
Canna × *generalis* (ornamentals)
  Canna × *orchiodes*
Cannabis sativa (medicinal plants)
  Cannabis indica
Capparis fascicularis (medicinal plants)
  Capparis elaeagnoides
  Capparis rothii
Carapa procera (medicinal plants)
  Carapa grandiflora
Carica papaya (fruits)
Carthamus tinctorius (vegetable oils)
Caryota urens (carbohydrates)
Cassia sieberiana (medicinal plants)
Catha edulis (stimulants)
  Catha inermis
  Celastrus edulis
Caucanthus auriculatus (forages)
Celtis africana (timbers)
Celtis toka (auxiliary plants)
  Celtis integrifolia
Cenchrus ciliaris (forages)
Cercestis mirabilis (vegetables)
  Nephtytis picturata
  Rhektophyllum congense
  Rhektophyllum mirabile
Ceriops tagal (dyes and tannins)
  Ceriops boiviniana
  Ceriops candolleana
Chaetocarpus africanus (fuel plants)
Chamaecrista kirkii (auxiliary plants)
  Cassia kirkii
Chamaecrista lateriticola (medicinal plants)
Chamaecrista mimosoides (auxiliary plants)
  Cassia mimosoides
Chasmanthera dependens (medicinal plants)
Chasmanthera welwitschii (medicinal plants)
Chasmopodium afzelii (forages)
Chloris gayana (forages)
Chonemorpha macrophylla (ornamentals)
Christiana africana (timbers)
Cinchona ledgeriana (medicinal plants)
Cissampelos mucronata (medicinal plants)
Cissampelos owariensis (medicinal plants)
  Cissampelos macrosepala
Cissampelos pareira (medicinal plants)
  Cissampelos madagascariensis
Cissus populnea (carbohydrates)
Clausena anisata (medicinal plants)
Cleistopholis glauca (timbers)
Cleistopholis patens (timbers)
Cleistopholis staudtii (timbers)
Clematis hirsuta (medicinal plants)
Clematis simensis (medicinal plants)
Clitoria lasciva (medicinal plants)

- *Cnestis ferruginea* (medicinal plants)
- *Cocculus hirsutus* (medicinal plants)
- *Cocculus orbiculatus* (medicinal plants)
- *Cochlospermum religiosum* (essential oils and exudates)
  - *Cochlospermum gossypium*
- *Cochlospermum tinctorium* (dyes and tannins)
- *Cochlospermum vitifolium* (ornamentals)
- *Cocos nucifera* (vegetable oils)
- *Coelocaryon preussii* (timbers)
  - *Coelocaryon klainei*
- *Coix lacryma-jobi* (cereals and pulses)
- *Cola gigantea* (ornamentals)
- *Cola lateritia* (timbers)
- *Cola laurifolia* (timbers)
- *Cola nitida* (stimulants)
- *Colocasia esculenta* (vegetables, carbohydrates)
  - *Colocasia antiquorum*
- *Colophospermum mopane* (timbers)
  - *Copaifera mopane*
- *Combretum adenogonium* (medicinal plants)
  - *Combretum fragrans*
  - *Combretum ghasalense*
  - *Combretum ternifolium*
- *Combretum coccineum* (medicinal plants)
  - *Poivrea coccinea*
  - *Combretum pachycladum*
- *Combretum collinum* (medicinal plants)
  - *Combretum binderanum*
  - *Combretum geitonophyllum*
  - *Combretum hypopilinum*
  - *Combretum lamprocarpum*
- *Combretum lecardii* (medicinal plants)
- *Combretum micranthum* (medicinal plants)
  - *Combretum raimbaultii*
- *Combretum paniculatum* (medicinal plants)
- *Combretum psidioides* (essential oils and exudates)
- *Combretum tomentosum* (medicinal plants)
- *Combretum zeyheri* (medicinal plants)
- *Commiphora africana* (essential oils and exudates)
- *Commiphora rostrata* (vegetables)
- *Copaifera religiosa* (timbers)
- *Corchorus depressus* (auxiliary plants)
- *Corchorus fascicularis* (forages)
- *Corchorus tridens* (vegetables)
- *Corchorus trilocularis* (vegetables)
- *Cordia africana* (timbers)
  - *Cordia abyssinica*
- *Cordia monoica* (fruits)
  - *Cordia ovalis*
  - *Cordia quarensis*
- *Cordia myxa* (medicinal plants)
- *Cordia senegalensis* (timbers)
- *Cordia sinensis* (fruits)
  - *Cordia gharaf*
  - *Cordia nevillii*
  - *Cordia quercifolia*
  - *Cordia rothii*
- *Cordyline terminalis* (ornamentals)
- *Costus afer* (medicinal plants)
- *Craterispermum laurinum* (dyes and tannins)
- *Craterispermum schweinfurthii* (dyes and tannins)
- *Crotalaria brevidens* (vegetables)
  - *Crotalaria intermedia*
- *Crotalaria incana* (auxiliary plants)
- *Crotalaria ochroleuca* (vegetables)
  - *Crotalaria cannabina*
- *Crotalaria pallida* (auxiliary plants)
  - *Crotalaria falcata*
  - *Crotalaria striata*
- *Crotalaria retusa* (auxiliary plants)
- *Croton aubrevillei* (medicinal plants)
- *Cryptolepis sanguinolenta* (dyes and tannins, medicinal plants)
- *Cryptostegia grandiflora* (essential oils and exudates)
- *Cryptostegia madagascariense* (essential oils and exudates)
- *Ctenolophon englerianus* (timbers)
- *Culcasia scandens* (medicinal plants)
  - *Culcasia lancifolia*
- *Curculigo capitulata* (ornamentals)
  - *Molineria capitulata*
- *Cycas rumphii* (ornamentals)
  - *Cycas circinalis*
- *Cymbopogon citratus* (essential oils and exudates)
- *Cymbopogon commutatus* (forages)
- *Cymbopogon giganteus* (medicinal plants)
  - *Cymbopogon caesius*
  - *Cymbopogon excavatus*
- *Cymbopogon nardus* (essential oils and exudates)
  - *Cymbopogon validus*
- *Cymbopogon schoenanthus* (medicinal plants)
  - *Cymbopogon proximus*
- *Cynanchum altiscandens* (forages)
- *Cynodon nlemfuensis* (forages)
- *Cyperus alopecuroides* (forages)
- *Cyperus alternifolius* (ornamentals)
- *Cyperus articulatus* (essential oils and exudates)
- *Cyperus dichroostachyus* (forages)
- *Cyperus digitatus* (essential oils and exudates)
  - *Cyperus auricomus*
- *Cyperus dives* (medicinal plants)
  - *Cyperus immensus*
- *Cyperus esculentus* (carbohydrates)
- *Cyperus exaltatus* (medicinal plants)
- *Cyperus haspan* (ornamentals)

Cyperus imbricatus (forages)
Cyperus iria (forages)
Cyperus laevigatus (forages)
Cyperus prolifer (medicinal plants)
  Cyperus aequalis
Cyperus renschii (medicinal plants)
Cyperus rotundus (medicinal plants)
  Cyperus fenzelianus
  Cyperus tuberosus
Cyperus sexangularis (medicinal plants)
Cyphostemma adenocaule (vegetables)
  Cissus adenocaulis
Dacryodes igaganga (timbers)
Dacryodes normandii (timbers)
Dactyloctenium aegyptium (forages)
Dalbergia armata (medicinal plants)
Dalbergia lactea (medicinal plants)
Daniellia alsteeniana (fuel plants)
Daniellia klainei (timbers)
Daniellia ogea (timbers)
Daniellia oliveri (timbers)
Daniellia thurifera (timbers)
Delonix elata (ornamentals)
Dennettia tripetala (spices and condiments)
Desmodium gangeticum (auxiliary plants)
Desmodium repandum (auxiliary plants)
Desmostachya bipinnata (forages)
Detarium microcarpum (medicinal plants)
Dialium guineense (fruits)
Diaphananthe bidens (ornamentals)
Dichapetalum madagascariense (medicinal plants)
  Dichapetalum guineense
  Dichapetalum subcordatum
  Dichapetalum thomsonii
Dichrostachys cinerea (medicinal plants)
  Dichrostachys glomerata
  Dichrostachys nyassana
Dictyophleba lucida (essential oils and exudates)
Digitaria diagonalis (forages)
Digitaria gayana (forages)
Digitaria longiflora (forages)
Diheteropogon amplectens (forages)
  Andropogon amplectens
  Andropogon diversifolius
Diplorhynchus condylocarpon (medicinal plants)
  Diplorhynchus mossambicensis
Discopodium penninervium (auxiliary plants)
Dobera glabra (fruits)
Dodonaea madagascariensis (forages)
Dodonaea viscosa (medicinal plants)
  Dodonaea angustifolia
Dombeya rotundifolia (timbers)
Dombeya torrida (timbers)
  Dombeya goetzenii
  Dombeya leucoderma
  Dombeya schimperiana
Dovyalis abyssinica (medicinal plants)
Dracaena angustifolia (medicinal plants)
Dracaena aubryana (ornamentals)
  Dracaena humilis
  Dracaena thalioides
Dracaena fragrans (ornamentals)
  Dracaena deisteliana
  Dracaena deremensis
  Dracaena smithii
Dracaena mannii (ornamentals)
  Dracaena perrottetii
  Dracaena usambarensis
Dracaena steudneri (ornamentals)
Drynaria laurentii (ornamentals)
Drypetes chevalieri (medicinal plants)
Drypetes floribunda (timbers)
  Drypetes ovata
Duparquetia orchidacea (ornamentals)
Dypsis decaryi (Jum.) (ornamentals)
  Neodypsis decaryi
Dypsis mananjarensis (vegetables)
  Chrysalidocarpus fibrosus
  Chrysalidocarpus mananjarensis
Dypsis nodifera (carbohydrates)
  Phloga polystachya var. *stenophylla*
Echinochloa pyramidalis (forages)
Echinochloa stagnina (cereals and pulses)
  Echinochloa scabra
Ehretia cymosa (timbers)
Eichhornia crassipes (auxiliary plants)
Elaeis guineensis (vegetable oils)
Eleocharis dulcis (carbohydrates)
  Eleocharis plantaginea
Elephantorrhiza goetzei (medicinal plants)
Eleusine coracana (cereals and pulses)
  Eleusine indica subsp. *coracana*
Eleusine indica (forages)
Elionurus elegans (forages)
Elionurus royleanus (forages)
Encephalartos hildebrandtii (carbohydrates)
Ensete gillettii (carbohydrates)
Ensete ventricosum (carbohydrates)
  Ensete edule
  Musa ensete
  Musa ventricosa
Entada abyssinica (medicinal plants)
Entada africana (medicinal plants)
  Entada sudanica
Enteropogon macrostachyus (forages)
Enteropogon rupestris (forages)
Eragrostis atrovirens (forages)
Eragrostis cilianensis (forages)
  Eragrostis megastachya

Eragrostis ciliaris (forages)
Eragrostis lehmanniana (forages)
Eragrostis plana (cereals and pulses)
Eragrostis tremula (forages)
Eriochloa fatmensis (forages)
  Eriochloa acrotricha
  Eriochloa nubica
Eriosema griseum (medicinal plants)
Erythrina senegalensis (ornamentals)
Erythrina variegata (auxiliary plants)
  Erythrina indica
Etlingera elatior (ornamentals)
Eucalyptus camaldulensis (timbers, fuel plants)
  Eucalyptus rostrata
Eucalyptus grandis (timbers)
Eucalyptus obliqua (timbers)
Euclea divinorum (dyes and tannins)
  Euclea keniensis
Euclea natalensis (medicinal plants)
  Euclea fructuosa
Euclea pseudebenus (timbers)
Euclea racemosa (fruits)
  Euclea schimperi
Eugenia coronata (ornamentals)
Eugenia leonensis (ornamentals)
Eulophia abyssinica (ornamentals)
  Eulophia zeyheri
Fagopyrum esculentum (cereals and pulses)
Faidherbia albida (auxiliary plants)
  Acacia albida
Ficus asperifolia (medicinal plants)
  Ficus acutifolia
  Ficus pendula
  Ficus urceolaris
  Ficus warburgii
Ficus benjamina (ornamentals)
Ficus glumosa (dyes and tannins)
  Ficus sonderi
Ficus ingens (auxiliary plants)
  Ficus katagumica
  Ficus kawuri
Ficus lutea (ornamentals)
  Ficus baronii
  Ficus trichosphaera
  Ficus vogelii
Ficus ovata (ornamentals)
  Ficus brachypoda
Ficus platyphylla (essential oils and exudates)
Ficus polita (ornamentals)
  Ficus megapoda
Ficus populifolia (medicinal plants)
Ficus stuhlmannii (medicinal plants)
Ficus sur (timbers)
  Ficus capensis
  Ficus mallotocarpa
  Ficus riparia
Ficus sycomorus (fruits)
  Ficus cocculifolia
  Ficus gnaphalocarpa
  Ficus sakalavarum
Ficus thonningii (auxiliary plants)
  Ficus basarensis
  Ficus dekdekena
  Ficus hochstetteri
  Ficus iteophylla
  Ficus persicifolia
  Ficus petersii
Ficus tiliifolia (fruits)
  Ficus trichophlebia
Ficus trichopoda (fruits)
  Ficus congensis
Ficus umbellata (ornamentals)
Ficus vallis-choudae (fruits)
Ficus variifolia (timbers)
  Ficus bongouanouensis
  Ficus zenkeri
Ficus vogeliana (timbers)
Fimbristylis dichotoma (auxiliary plants)
Fimbristylis ferruginea (auxiliary plants)
Flueggea virosa (medicinal plants)
  Flueggea microcarpa
  Securinega microcarpa
  Securinega virosa
Friesodielsia obovata (fruits)
  Popowia obovata
Funtumia africana (essential oils and exudates)
  Funtumia latifolia
Funtumia elastica (essential oils and exudates)
Gaertnera paniculata (timbers)
Garcinia afzelii (medicinal plants)
Garcinia epunctata (medicinal plants)
Garcinia huillensis (fruits)
Garcinia kola (stimulants)
Garcinia mangostana (fruits)
Gilbertiodendron dewevrei (timbers)
  Macrolobium dewevrei
Glycosmis parviflora (medicinal plants)
  Glycosmis citrifolia
  Limonia parviflora
Glyphaea brevis (auxiliary plants)
Gmelina arborea (timbers)
Gnetum africanum (vegetables)
  Thoa africana
Gnetum buchholzianum (vegetables)
  Thoa buchholziana
Gomphocarpus fruticosus (medicinal plants)
  Asclepias decipiens
  Asclepias fruticosa
Gongronema latifolium (medicinal plants)
  Marsdenia latifolia
Grewia barteri (fuel plants)

- *Grewia bicolor* (timbers)
- *Grewia carpinifolia* (forages)
- *Grewia falcistipula* (fruits)
- *Grewia ferruginea* (timbers)
- *Grewia flava* (fruits)
- *Grewia flavescens* (fruits)
  - *Grewia platyclada*
- *Grewia mollis* (timbers)
  - *Grewia pubescens*
  - *Grewia venusta*
- *Grewia pinnatifida* (timbers)
- *Grewia similis* (fruits)
- *Grewia tenax* (fruits)
- *Grewia velutina* (fruits)
- *Grewia villosa* (fruits)
- *Griffonia physocarpa* (dyes and tannins)
  - *Bandeiraea tenuiflora*
- *Griffonia simplicifolia* (medicinal plants)
  - *Bandeiraea simplicifolia*
- *Guazuma ulmifolia* (ornamentals)
- *Guiera senegalensis* (medicinal plants)
- *Guizotia scabra* (vegetables)
- *Gymnosporia acuminata* (medicinal plants)
  - *Maytenus acuminata*
- *Gynerium sagittatum* (ornamentals)
- *Gyrocarpus americanus* (timbers)
  - *Gyrocarpus asiaticus*
  - *Gyrocarpus jacquinii*
- *Harungana madagascariensis* (medicinal plants)
  - *Haronga madagascariensis*
- *Hedychium coronarium* (ornamentals)
- *Helianthus annuus* (vegetable oils)
- *Helicteres isora* (fuel plants)
- *Heliotropium indicum* (medicinal plants)
- *Hemarthria altissima* (forages)
  - *Hemarthria fasciculata*
- *Heritiera littoralis* (timbers)
  - *Heritiera minor*
- *Hevea brasiliensis* (essential oils and exudates)
- *Hewittia malabarica* (vegetables)
  - *Convolvulus malabaricus*
  - *Hewittia scandens*
  - *Hewittia sublobata*
- *Hexalobus crispiflorus* (timbers)
- *Hexalobus monopetalus* (fruits)
- *Hibiscus asper* (vegetables)
  - *Hibiscus cannabinus* var. *punctatus*
- *Hibiscus calyphyllus* (vegetables)
  - *Hibiscus calycinus*
- *Hibiscus lasiococcus* (timbers)
  - *Hibiscus domatiocarpus*
- *Hibiscus ludwigii* (medicinal plants)
- *Hibiscus macranthus* (medicinal plants)
- *Hibiscus mechowii* (vegetables)
- *Hibiscus noldeae* (vegetables)
- *Hibiscus physaloides* (medicinal plants)
- *Hibiscus rhodanthus* (medicinal plants)
- *Hibiscus rosa-sinensis* (ornamentals)
- *Hibiscus rostellatus* (medicinal plants)
- *Hibiscus surattensis* (vegetables)
- *Hildegardia barteri* (auxiliary plants)
- *Holarrhena floribunda* (medicinal plants)
  - *Holarrhena africana*
  - *Holarrhena wulfsbergii*
- *Holarrhena pubescens* (medicinal plants)
  - *Holarrhena antidysenterica*
  - *Holarrhena febrifuga*
- *Hordeum vulgare* (cereals and pulses)
  - *Hordeum sativum*
- *Hymenocardia acida* (medicinal plants)
- *Hymenostegia afzelii* (ornamentals)
- *Hyparrhenia collina* (forages)
- *Hyparrhenia cymbaria* (forages)
  - *Cymbopogon cymbarius*
- *Hyparrhenia figariana* (forages)
- *Hyparrhenia newtonii* (forages)
  - *Cymbopogon lecomtei*
  - *Hyparrhenia lecomtei*
- *Hyparrhenia quarrei* (forages)
- *Hyparrhenia rufa* (forages)
  - *Cymbopogon rufus*
- *Hyparrhenia umbrosa* (forages)
- *Hyparrhenia welwitschii* (forages)
- *Hyphaene compressa* (carbohydrates)
- *Hyphaene coriacea* (carbohydrates)
  - *Hyphaene hildebrandtii*
  - *Hyphaene natalensis*
  - *Hyphaene shatan*
- *Hyphaene crinita* (fruits)
- *Hyphaene petersiana* (carbohydrates)
  - *Hyphaene benguellensis*
  - *Hyphaene ventricosa*
- *Icacina oliviformis* (medicinal plants)
  - *Icacina senegalensis*
- *Icacina trichantha* (carbohydrates)
- *Indigofera nigritana* (medicinal plants)
- *Indigofera paniculata* (medicinal plants)
- *Indigofera pulchra* (medicinal plants)
- *Indigofera simplicifolia* (medicinal plants)
- *Indigofera spicata* (auxiliary plants)
  - *Indigofera hendecaphylla*
- *Ipomoea asarifolia* (medicinal plants)
  - *Ipomoea repens*
- *Ipomoea cairica* (ornamentals)
  - *Ipomoea palmata*
- *Ipomoea pes-caprae* (auxiliary plants, medicinal plants)
- *Isomacrolobium explicans* (timbers)
  - *Anthonotha explicans*
  - *Triplisomeris explicans*
- *Jasminum abyssinicum* (spices and condiments)

- *Jasminum fluminense* (ornamentals)
  - *Jasminum mauritianum*
- *Jatropha parvifolia* (medicinal plants)
- *Julbernardia paniculata* (fuel plants)
- *Julbernardia seretii* (timbers)
- *Kalanchoe lanceolata* (medicinal plants)
  - *Kalanchoe brachycalyx*
- *Kanahia laniflora* (medicinal plants)
- *Khaya senegalensis* (timbers)
- *Kirkia acuminata* (timbers)
- *Kleinhovia hospita* (ornamentals)
- *Koeleria capensis* (forages)
- *Kolobopetalum chevalieri* (medicinal plants)
- *Kotschya africana* (medicinal plants)
  - *Smithia chamaecrista*
- *Kotschya strigosa* (medicinal plants)
- *Landolphia buchananii* (fruits)
  - *Landolphia kilimanjarica*
- *Landolphia incerta* (essential oils and exudates)
  - *Aphanostylis mannii*
- *Landolphia owariensis* (essential oils and exudates)
- *Landolphia robustior* (essential oils and exudates)
  - *Anthoclitandra robustior*
- *Lannea acida* (medicinal plants)
- *Lannea alata* (fruits)
- *Lannea barteri* (dyes and tannins)
  - *Lannea kerstingii*
- *Lannea discolor* (fruits)
- *Lannea egregia* (dyes and tannins)
- *Lannea fulva* (fruits)
- *Lannea humilis* (medicinal plants)
- *Lannea microcarpa* (dyes and tannins)
- *Lannea rivae* (fruits)
- *Lannea schweinfurthii* (fruits)
  - *Lannea stuhlmannii*
- *Lannea triphylla* (fruits)
- *Lannea velutina* (dyes and tannins)
- *Lantana trifolia* (medicinal plants)
- *Laportea ovalifolia* (vegetables)
  - *Fleurya ovalifolia*
  - *Fleurya podocarpa*
- *Lasimorpha senegalensis* (vegetables)
  - *Cyrtosperma senegalense*
  - *Lasimorpha afzelii*
- *Lasiodiscus mannii* (timbers)
- *Lasiurus scindicus* (forages)
  - *Lasiurus hirsutus*
- *Latania lontaroides* (ornamentals)
- *Latania verschaffeltii* (ornamentals)
- *Lawsonia inermis* (dyes and tannins)
  - *Lawsonia alba*
- *Leptadenia pyrotechnica* (medicinal plants)
- *Leptochloa fusca* (forages)
  - *Diplachne fusca*
- *Leucaena leucocephala* (auxiliary plants)
  - *Leucaena glauca*
- *Livistona chinensis* (ornamentals)
- *Lonchocarpus sericeus* (ornamentals)
- *Loudetia kagerensis* (forages)
- *Lovoa trichilioides* (timbers)
  - *Lovoa brownii*
  - *Lovoa klaineana*
- *Luffa acutangula* (vegetables)
  - *Cucumis acutangulus*
- *Lycopodiella cernua* (medicinal plants)
  - *Lepidotis cernua*
  - *Lycopodium cernuum*
  - *Palhinhaea cernua*
- *Lycopodium clavatum* (medicinal plants)
  - *Lepidotis clavata*
  - *Lycopodium officinale*
  - *Lycopodium trichiatum*
- *Lygodium smithianum* (medicinal plants)
- *Macaranga saccifera* (medicinal plants)
- *Macaranga schweinfurthii* (fuel plants)
- *Maerua crassifolia* (medicinal plants)
- *Maesa lanceolata* (medicinal plants)
- *Mallotus oppositifolius* (medicinal plants)
- *Malvastrum coromandelianum* (medicinal plants)
- *Manotes expansa* (medicinal plants)
  - *Manotes longiflora*
  - *Manotes pruinosa*
- *Maprounea africana* (medicinal plants)
- *Maranta arundinacea* (carbohydrates)
- *Margaritaria anomala* (medicinal plants)
  - *Phyllanthus erythroxyloides*
- *Mariscus cylindristachyus* (spices and condiments)
- *Mariscus longibracteatus* (forages)
- *Markhamia obtusifolia* (timbers)
- *Marsdenia abyssinica* (medicinal plants)
  - *Dregea abyssinica*
  - *Dregea africana*
- *Marsdenia schimperi* (medicinal plants)
  - *Dregea schimperi*
- *Melaleuca leucadendron* (essential oils and exudates)
- *Melanthera scandens* (medicinal plants)
  - *Melanthera brownei*
- *Melochia corchorifolia* (vegetables)
- *Melochia melissifolia* (vegetables)
- *Meriandra bengalensis* (essential oils and exudates)
- *Merremia hederacea* (forages)
- *Microdesmis keayana* (medicinal plants)
- *Microdesmis puberula* (medicinal plants)
  - *Microdesmis zenkeri*
- *Milicia excelsa* (timbers)
  - *Chlorophora excelsa*

  Maclura excelsa
Milicia regia (timbers)
  Chlorophora regia
Millettia pallens (timbers)
Millettia thonningii (medicinal plants)
Millingtonia hortensis (ornamentals)
Mimosa pigra (medicinal plants)
Mitragyna rubrostipulata (timbers)
  Hallea rubrostipulata
Momordica foetida (vegetables)
Monanthotaxis caffra (medicinal plants)
  Popowia caffra
Monanthotaxis ferruginea (medicinal plants)
  Popowia ferruginea
Mondia whitei (medicinal plants)
Monocymbium ceresiiforme (forages)
Monodora tenuifolia (spices and condiments)
Morinda citrifolia (medicinal plants)
Morinda lucida (dyes and tannins)
Moringa oleifera (vegetables)
  Moringa pterygosperma
Moringa stenopetala (vegetables)
Morus alba (forages)
Morus mesozygia (timbers)
  Morus lactea
Mostuea hirsuta (medicinal plants)
  Mostuea gabonica
Motandra lujaei (medicinal plants)
Mucuna flagellipes (dyes and tannins)
Mucuna poggei (dyes and tannins)
  Mucuna pesa
  Mucuna rubro-aurantiaca
Mucuna pruriens (auxiliary plants)
  Mucuna aterrima
  Mucuna cochinchiniensis
  Mucuna nivea
Mundulea sericea (medicinal plants)
Musa [dessert cultivars] (fruits)
Musanga cecropioides (timbers)
Mussaenda elegans (ornamentals)
Myrianthus arboreus (vegetables)
Myrsine africana (medicinal plants)
Napoleonaea imperialis (ornamentals)
  Napoleonaea mannii
Napoleonaea vogelii (ornamentals)
  Napoleonaea leonensis
  Napoleonaea parviflora
Neonotonia wightii (forages)
  Glycine wightii
Nesogordonia kabingaensis (timbers)
  Cistanthera fouassieri
  Cistanthera kabingaensis
  Cistanthera leplaei
  Cistanthera papaverifera
  Nesogordonia fouassieri
  Nesogordonia leplaei
  Nesogordonia papaverifera
Nuxia congesta (timbers)
  Lachnopylis sambesina
Nypa fruticans (carbohydrates)
  Nipa fructicans
Odyendyea gabonensis (timbers)
  Quassia gabonensis
Olax gambecola (medicinal plants)
  Olax viridis
Olax subscorpioidea (medicinal plants)
Oncinotis glabrata (medicinal plants)
  Oncinotis glandulosa
Opilia amentacea (medicinal plants)
  Opilia celtidifolia
Opuntia tuna (auxiliary plants)
Opuntia vulgaris (forages)
  Opuntia monacantha
Oreobambos buchwaldii (timbers)
Orthanthera albida (medicinal plants)
Oryza longistaminata (cereals and pulses)
Oryza sativa (cereals and pulses)
Osmunda regalis (ornamentals)
Ostryocarpus riparius (medicinal plants)
Osyris lanceolata (essential oils and exudates)
  Osyris abyssinica
  Osyris lanceolata
  Osyris quadripartita
  Osyris tenuifolia
Otoptera madagascariensis (medicinal plants)
Otostegia integrifolia (medicinal plants)
Oxytenanthera abyssinica (timbers)
  Oxytenanthera borzii
Pachypodanthium staudtii (timbers)
Pachypodium brevicaule (ornamentals)
Pachypodium geayi (ornamentals)
Pachypodium rosulatum (ornamentals)
Pachypodium rutenbergianum (essential oils and exudates)
Pachypodium sofiense (ornamentals)
Pachyrhizus erosus (carbohydrates)
Palisota schweinfurthii (medicinal plants)
Pandanus balfourii (medicinal plants)
Pandanus veitchii (ornamentals)
Panicum anabaptistum (forages)
Panicum maximum (forages)
  Panicum jumentorum
Panicum miliaceum (cereals and pulses)
Panicum phragmitoides (auxiliary plants)
Panicum porphyrrhizos (forages)
Panicum trichocladum (forages)
Panicum turgidum (cereals and pulses)
Paramacrolobium coeruleum (timbers)
  Macrolobium dawei
Paraserianthes falcataria (auxiliary plants)
  Albizia falcataria

Albizia moluccana
Falcataria moluccana
Parinari curatellifolia (fruits)
Parinari mobola
Parkia biglobosa (spices and condiments)
Mimosa biglobosa
Parkia africana
Parkia clappertoniana
Parkia oliveri
Parkinsonia aculeata (auxiliary plants)
Parkinsonia anacantha (forages)
Parquetina nigrescens (medicinal plants)
Periploca nigrescens
Paspalum scrobiculatum (forages)
Paspalum lamprocaryon
Paspalum orbiculare
Paspalum polystachyum
Paullinia pinnata (medicinal plants)
Pauridiantha callicarpoides (medicinal plants)
Urophyllum callicarpoides
Pavonia zeylanica (forages)
Pennisetum glaucum (cereals and pulses)
Pennisetum americanum
Pennisetum spicatum
Pennisetum typhoides
Pennisetum pedicellatum (forages)
Pennisetum polystachion (forages)
Pennisetum atrichum
Pennisetum setosum
Pennisetum subangustum
Pennisetum triticoides
Pennisetum purpureum (forages)
Pennisetum setaceum (ornamentals)
Pennisetum erythraeum
Pentadesma butyracea (vegetable oils)
Pergularia daemia (medicinal plants)
Pergularia extensa
Periploca aphylla (medicinal plants)
Periploca linearifolia (medicinal plants)
Pervillaea decaryi (fuel plants)
Toxocarpus decaryi
Phoenix dactylifera (fruits)
Phyllanthus casticum (medicinal plants)
Phyllanthus engleri (medicinal plants)
Phyllanthus fischeri (medicinal plants)
Phyllanthus muellerianus (medicinal plants)
Phyllanthus floribundus
Phyllanthus reticulatus (medicinal plants)
Phyllanthus sepialis (medicinal plants)
Phyllanthus seyrigii (medicinal plants)
Phyllocosmus lemaireanus (timbers)
Ochthocosmos lemaireanus
Phytolacca dioica (medicinal plants)
Phytolacca dodecandra (medicinal plants)
Pinus caribaea (timbers)
Piptadeniastrum africanum (timbers)
Piptadenia africana
Pistacia aethiopica (essential oils and exudates)
Pistacia lentiscus var. *emarginata*
Pittosporum viridiflorum (medicinal plants)
Pittosporum mannii
Pittosporum spathicalyx
Plantago palmata (medicinal plants)
Pluchea ovalis (forages)
Pongamia pinnata (medicinal plants)
Pouteria alnifolia (timbers)
Malacantha alnifolia
Malacantha heudelotiana
Prioria oxyphylla (timbers)
Oxystigma oxyphyllum
Pterygopodium oxyphyllum
Pristimera andongensis (medicinal plants)
Hippocratea andongensis
Hippocratea volkensii
Pristimera paniculata (medicinal plants)
Hippocratea paniculata
Prosopis africana (fuel plants)
Prosopis glandulosa (auxiliary plants)
Pseudarthria hookeri (medicinal plants)
Psiadia punctulata (medicinal plants)
Psiadia arabica
Psilanthus ebracteolatus (dyes and tannins)
Coffea ebractiolata
Psychotria avakubiensis (timbers)
Pteleopsis suberosa (medicinal plants)
Pterocarpus angolensis (dyes and tannins, timbers)
Pterocarpus bussei
Pterygota macrocarpa (timbers)
Pueraria lobata (auxiliary plants)
Pueraria thunbergiana
Pueraria phaseoloides (auxiliary plants)
Pycnanthus angolensis (timbers, vegetable oils)
Pycnanthus kombo
Pycnobotrya nitida (medicinal plants)
Pycnobotrya multiflora
Pycreus nitidus (spices and condiments)
Quisqualis indica (medicinal plants)
Rauvolfia caffra (medicinal plants)
Rauvolfia macrophylla
Ravenala madagascariensis (ornamentals)
Ravenea robustior (vegetables)
Reissantia indica (medicinal plants)
Hippocratea indica
Hippocratea loeseneriana
Rhigiocarya racemifera (medicinal plants)
Rhizophora harrisonii (fuel plants)
Rhizophora mangle (fuel plants)
Rhizophora mucronata (fuel plants)
Rhizophora racemosa (fuel plants)
Rhodognaphalon brevicuspe (timbers)

  Bombax brevicuspe
  Bombax chevalieri
Rhodognaphalon schumannianum (timbers)
  Bombax mossambicense
  Bombax rhodognaphalon
  Bombax stolzii
  Rhodognaphalon mossambicense
  Rhodognaphalon stolzii
  Rhodognaphalon tanganyikense
Rhoicissus revoilii (medicinal plants)
Rhoicissus tomentosa (fruits)
Rhoicissus tridentata (medicinal plants)
  Rhoicissus erythrodes
Rhynchosia hirta (forages)
  Rhynchosia albiflora
Rhynchosia pycnostachya (medicinal plants)
Rhynchospora corymbosa (auxiliary plants)
Rhytachne triaristata (forages)
Ricinodendron heudelotii (timbers, vegetable oils)
  Ricinodendron africanum
Rinorea arborea (timbers)
  Alsodeia arborea
Rinorea subintegrifolia (medicinal plants)
Rothmannia longiflora (dyes and tannins)
  Randia maculata
  Rothmannia maculata
Rottboellia cochinchinensis (forages)
  Rottboellia exaltata
Roystonea regia (ornamentals)
  Oreodoxa regia
Rumex usambarensis (auxiliary plants)
Saccharum officinarum (carbohydrates)
Saccharum spontaneum (auxiliary plants)
Salix subserrata (fuel plants)
Salvadora persica (fruits)
Sambucus nigra (medicinal plants)
  Sambucus mexicana
Sansevieria kirkii (medicinal plants)
Sansevieria trifasciata (ornamentals)
Sapindus saponaria (ornamentals)
Scaphopetalum amoenum (medicinal plants)
Schefflera barteri (ornamentals)
  Schefflera hierniana
Schinziophyton rautanenii (vegetable oils)
  Ricinodendron rautanenii
Schizachyrium brevifolium (forages)
Schizachyrium exile (forages)
Schizachyrium sanguineum (forages)
  Andropogon hirtiflorum
  Schizachyrium semiberbe
Schlechterina mitostemmatoides (medicinal plants)
Schoenefeldia gracilis (forages)
Schoenoplectus corymbosus (forages)
  Schoenoplectus brachyceras
  Scirpus brachyceras
  Scirpus corymbosus
Schumanniophyton magnificum (medicinal plants)
Schwenckia americana (medicinal plants)
Sclerocarya birrea (fruits)
  Poupartia birrea
  Poupartia caffra
  Sclerocarya caffra
Scoparia dulcis (medicinal plants)
Searsia crenulata (fruits)
  Rhus crenulata
Searsia glaucescens (fruits)
  Rhus glaucescens
Searsia glutinosa (timbers)
  Rhus abyssinica
  Rhus glutinosa
Searsia natalensis (fruits)
  Rhus natalensis
Searsia retinorrhoea (timbers)
  Rhus retinorrhoea
Searsia tomentosa (dyes and tannins)
  Rhus tomentosa
Secale cereale (cereals and pulses)
Secamone afzelii (medicinal plants)
Secamone punctulata (medicinal plants)
Secamone stuhlmannii (vegetables)
  Secamone floribunda
  Secamone phillyreoides
  Secamone rariflora
  Secamone whytei
Sechium edule (vegetables)
Securidaca longipedunculata (medicinal plants)
Senna auriculata (dyes and tannins)
  Cassia auriculata
Senna baccarinii (medicinal plants)
  Cassia baccarinii
Senna obtusifolia (vegetables)
  Cassia obtusifolia
Senna singueana (medicinal plants)
  Cassia goratensis
  Cassia singueana
Sesamothamnus rivae (medicinal plants)
Sesbania bispinosa (auxiliary plants)
Sesbania grandiflora (ornamentals)
Sesbania macrantha (auxiliary plants)
Sesbania pachycarpa (forages)
Sesbania rostrata (auxiliary plants)
Sesbania sesban (auxiliary plants)
  Sesbania aegyptiaca
Setaria incrassata (forages)
  Setaria ciliolata
Setaria italica (cereals and pulses)
Setaria megaphylla (forages)
  Setaria chevalieri

Setaria pumila (forages)
  Setaria pallide-fusca
Setaria sphacelata (forages)
  Setaria anceps
  Setaria aurea
Setaria verticillata (forages)
Sherbournia bignoniiflora (medicinal plants)
  Amaralia heinsioides
Sida acuta (medicinal plants)
  Sida carpinifolia
  Sida stipulata
Sida schimperiana (medicinal plants)
Sinarundinaria alpina (timbers)
  Arundinaria alpina
Sloanea rhodantha (timbers)
  Elaeocarpus quadrilobus
  Elaeocarpus rhodanthus
Smeathmannia pubescens (medicinal plants)
Smilax anceps (medicinal plants)
  Smilax kraussiana
Solanum mauritianum (ornamentals)
  Solanum auriculatum
Solanum terminale (medicinal plants)
  Solanum welwitschii
Sorghum arundinaceum (forages)
  Sorghum aethiopicum
  Sorghum verticilliflorum
  Sorghum virgatum
Sorghum bicolor (cereals and pulses, dyes and tannins)
Sorghum purpureo-sericeum (forages)
Sorindeia juglandifolia (fruits)
  Sorindeia claessensii
  Sorindeia submontana
Sphenostylis marginata (carbohydrates)
  Sphenostylis erecta
Sphenostylis schweinfurthii (carbohydrates)
Sporobolus africanus (forages)
Sporobolus festivus (forages)
Sporobolus helvolus (forages)
Sporobolus ioclados (forages)
Sporobolus myrianthus (forages)
Sporobolus natalensis (forages)
Sporobolus pyramidalis (forages)
  Sporobolus indicus p.p.
Steganotaenia araliacea (auxiliary plants)
  Peucedanum fraxinifolium
Stemonocoleus micranthus (timbers)
Stephania abyssinica (medicinal plants)
Stephania dinklagei (medicinal plants)
Sterculia dawei (fuel plants)
  Sterculia bequaertii
Sterculia oblonga (timbers)
  Eribroma oblonga
  Sterculia elegantiflora
Sterculia quinqueloba (timbers)
Sterculia setigera (essential oils and exudates)
Sterculia tragacantha (essential oils and exudates)
Stereospermum kunthianum (medicinal plants)
Stipagrostis pungens (forages)
Stipagrostis uniplumis (forages)
Stomatanthes africana (medicinal plants)
  Eupatorium africanum
Striga gesnerioides (dyes and tannins)
  Striga orobanchoides
Strombosia pustulata (timbers)
  Strombosia glaucescens
Strophanthus preussii (medicinal plants)
Strophanthus sarmentosus (medicinal plants)
Strychnopsis thouarsii (medicinal plants)
Strychnos afzelii (medicinal plants)
Strychnos innocua (fruits)
  Strychnos triclisioides
Strychnos malchairii (medicinal plants)
Strychnos melastomatoides (medicinal plants)
Stylosanthes erecta (forages)
Suaeda monoica (auxiliary plants)
Synaptolepis alternifolia (medicinal plants)
Synaptolepis kirkii (medicinal plants)
Synsepalum dulcificum (spices and condiments)
Syzygium cordatum (timbers)
Syzygium cumini (fruits)
  Eugenia jambolana
Tabernaemontana brachyantha (medicinal plants)
  Conopharyngia brachyantha
Tabernaemontana coffeoides (medicinal plants)
  Hazunta coffeoides
  Hazunta costata
  Hazunta modesta
  Hazunta velutina
Tabernaemontana pachysiphon (medicinal plants)
  Tabernaemontana angolensis
  Tabernaemontana holstii
Tacazzea apiculata (essential oils and exudates)
Tacca leontopetaloides (carbohydrates)
  Tacca involucrata
  Tacca pinnatifida
  Tacca umbrarum
Tamarindus indica (fruits)
Tamarix aphylla (timbers)
  Tamarix articulata
Tamarix senegalensis (timbers)
Tectona grandis (timbers)
Telfairia occidentalis (vegetables)
Tephrosia bracteolata (forages)
Tephrosia linearis (forages)
Tephrosia retamoides (medicinal plants)

Lebeckia retamoides
Tephrosia subtriflora (forages)
Tephrosia uniflora (forages)
Tephrosia vogelii (medicinal plants)
Teramnus uncinatus (forages)
Teramnus andongensis
Terminalia brachystemma (medicinal plants)
Terminalia brownii (medicinal plants)
Terminalia laxiflora (medicinal plants)
Terminalia sericea (timbers)
Tetracera potatoria (medicinal plants)
Tetrapogon tenellus (forages)
Tetrorchidium didymostemon (medicinal plants)
Tetrorchidium minus
Thaumatococcus daniellii (spices and condiments)
Themeda triandra (forages)
Themeda villosa (ornamentals)
Thespesia garckeana (fruits)
Azanza garckeana
Thespesia lampas (ornamentals)
Azanza lampas
Thespesia populnea (timbers)
Tiliacora leonensis (medicinal plants)
Tiliacora dielsiana
Tiliacora dinklagei
Tinnea aethiopica (ornamentals)
Tinnea barteri (ornamentals)
Tragia hildebrandtii (medicinal plants)
Tragus berteronianus (forages)
Treculia africana (fruits)
Treculia madagascarica
Treculia mollis
Treculia perrieri
Trema orientalis (auxiliary plants)
Trema guineensis
Trichilia monadelpha (timbers)
Limonia monadelpha
Trichilia heudelotii
Trichilia velutina
Trichilia prieureana (timbers)
Tricholaena monachne (auxiliary plants)
Triclisia patens (medicinal plants)
Triclisia subcordata (medicinal plants)
Trilepisium madagascariense (fruits)
Bosqueia angolensis
Bosqueia boiviniana
Bosqueia phoberos
Triplochiton scleroxylon (timbers)
Triplochiton nigericum
Tristachya superba (forages)
Triticum aestivum (cereals and pulses)
Triticum vulgare
Triticum turgidum (cereals and pulses)
Triticum dicoccon
Triticum durum
Triumfetta annua (vegetables)
Triumfetta brachyceras (medicinal plants)
Triumfetta macrophylla
Turraea mombassana (medicinal plants)
Tylosema fassoglense (cereals and pulses)
Bauhinia fassoglensis
Bauhinia kirkii
Typhonodorum lindleyanum (carbohydrates)
Typhonodorum madagascariense
Uapaca guineensis (timbers, medicinal plants)
Uapaca togoensis (fruits)
Uapaca somon
Urera cordifolia (vegetables)
Urera flamigniana (vegetables)
Urera trinervis (vegetables)
Elatostema trinervis
Urera cameroonensis
Usteria guineensis (medicinal plants)
Uvaria acuminata (fruits)
Uvaria catocarpa
Uvaria kirkii (fruits)
Uvaria lucida (medicinal plants)
Uvaria ovata (fruits)
Uvaria scabrida (medicinal plants)
Vatovaea pseudolablab (cereals and pulses)
Vepris simplicifolia (timbers)
Teclea simplicifolia
Vepris verdoorniana (medicinal plants)
Teclea verdoorniana
Vernonia adoensis (medicinal plants)
Vernonia kotschyana
Vernonia shirensis
Vernonia amygdalina (vegetables)
Gymnanthemum amygdalinum
Vernonia colorata (medicinal plants)
Vetiveria nigritana (auxiliary plants, essential oils and exudates)
Vetiveria zizanioides (auxiliary plants, essential oils and exudates)
Andropogon muricatus
Vigna frutescens (forages)
Vigna violacea
Vigna unguiculata (cereals and pulses, vegetables)
Vigna sinensis
Vigna vexillata (medicinal plants)
Vigna dinteri
Vigna phaseoloides
Vismia guineensis (medicinal plants)
Vitex agnus-castus (ornamentals)
Vitex madiensis (fuel plants)
Vitex barbata
Vitex camporum
Vitex diversifolia
Vitex simplicifolia
Voacanga africana (medicinal plants)

Voacanga angolensis
Voacanga thouarsii (medicinal plants)
Orchipeda thouarsii
Vossia cuspidata (forages)
Wikstroemia indica (medicinal plants)
Xeroderris stuhlmannii (timbers)
Ostryoderris stuhlmannii
Xylia evansii (timbers)
Xylopia acutiflora (timbers)
Xylopia aethiopica (spices and condiments)
Xylopia eminii
Xylopia hypolampra (timbers)
Xylopia brieyi
Xylopia odoratissima (medicinal plants)
Xylopia parviflora (spices and condiments)
Xylopia longipetala
Xylopia vallotii
Xylopia quintasii (timbers)
Xylopia rubescens (timbers)
Xylopia staudtii (timbers)
Xysmalobium undulatum (medicinal plants)
Zanthoxylum capense (medicinal plants)
Fagara capensis
Zanthoxylum chalybeum (medicinal plants)
Fagara chalybea
Zanthoxylum gilletii (timbers)
Fagara amaniensis
Fagara macrophylla
Fagara tessmannii
Zanthoxylum tessmannii
Zanthoxylum lemairei (medicinal plants)
Fagara lemairei
Zanthoxylum leprieurii (medicinal plants)
Fagara angolensis
Fagara leprieurii
Zanthoxylum rubescens (medicinal plants)
Fagara rubescens
Zanthoxylum usambarense (medicinal plants)
Fagara becquetii
Fagara usambarensis
Zanthoxylum becquetii
Zea mays (cereals and pulses)
Zehneria scabra (medicinal plants)
Melothria punctata
Ziziphus abyssinica (fruits)

Literature

Abbiw, D.K., 1990. Useful plants of Ghana: West African uses of wild and cultivated plants. Intermediate Technology Publications, London and Royal Botanic Gardens, Kew, Richmond, United Kingdom. 337 pp.

Abbiw, D.K., 1997. Traditional vegetables in Ghana. In: Guarino, L. (Editor). Traditional African vegetables. Proceedings of the IPGRI international workshop on genetic resources of traditional vegetables in Africa: conservation and use, 29–31 August 1995, ICRAF, Nairobi, Kenya. Promoting the conservation and use of underutilized and neglected crops 16. pp. 29–38.

Abbot, P.G. & Lowore, J.D., 1999. Characteristics and management potential of some indigenous firewood species in Malawi. Forest Ecology and Management 119(1–3): 111–121.

Abdullah, Y., Schneider, B. & Petersen, M., 2008. Occurrence of rosmarinic acid, chlorogenic acid and rutin in Marantaceae species. Phytochemistry Letters 1(4): 199–203.

Abdullahi, M., Buhari Salawu, F. & Abdulrauf, I., 2011. Antimicrobial activity of Bombax buonopozense P.Beauv. (Bombacaceae) edible floral extracts. European Journal of Scientific Research 48(4): 627–630.

Abe, K., Ozaki, Y. & Kihou, N., 1997. Introduction of fiber plants to plant bed filter systems for wastewater treatment in relation to resource recycling. Soil Science and Plant Nutrition 43(1): 35–43.

Abira, M.A., Ngirigacha, H.W. & van Bruggen, J.J., 2003. Preliminary investigation of the potential of four tropical emergent macrophytes for treatment of pre-treated pulp and papermill wastewater in Kenya. Water Science & Technology 48(5): 223–231.

Abira, M.A., van Bruggen, J.J.A. & Denny, P., 2005. Potential of a tropical subsurface constructed wetland to remove phenol from pre-treated pulp and papermill wastewater. Water Science and Technology 51(9): 173–175.

Acevedo-Rodríguez, P. & Strong, M.T. (Editors), 2005. Monocotyledons and gymnosperms of Puerto Rico and the Virgin Islands. Contributions from the United States National Herbarium 52: 1–415.

Achigan-Dako, E.G., 2008. Phylogenetic and genetic variation analyses in cucurbit species (Cucurbitaceae) from West Africa: definition of conservation strategies. Cuvillier Verlag, Göttingen, Germany. 154 pp.

Achigan-Dako, E.G., Pasquini, M.W., Assogba-Komlan, F., N'danikou, S., Yédomonhan, H., Dansi, A. & Ambrose-Oji, B., 2010. Traditional vegetables in Benin: diversity, distribution, ecology, agronomy, and utilisation. Institut National des Recherches Agricoles du Bénin, Benin. 252 pp.

Achinah, N.K.A., 2009. Phytochemical analysis and antioxidant properties of Imperata cylindrica. BSc. Biochemistry degree thesis, Department of Biochemistry and Biotechnology, Faculty of Biosciences, Kwame Nkrumah University of Science and Technology, Kumasi, Ghana. 46 pp.

Adam, J.G., Echard, N. & Lescot, M., 1972. Plantes médicinales Hausa de l'Ader. Journal d'Agriculture Tropicale et de Botanique Appliquée 19(8–9): 259–399.

Adams, C.D., 1963. Compositae. In: Hepper, F.N. (Editor). Flora of West Tropical Africa. Volume 2. 2nd Edition. Crown Agents for Oversea Governments and Administrations, London, United Kingdom. pp. 225–297.

Adams, C.D., 1972. Flowering plants of Jamaica. University of the West Indies, Mona, Jamaica. 848 pp.

Adamson, W.C. & Monton, N.A., 1982. Stem and root density in kenaf and roselle at different harvest dates (Hibiscus cannabinus, Hibiscus sabdariffa) for best fiber, as annual sources of paper pulp. Crop Science 21: 849–851.

Adamu, H.M., Abayeh, O.J., Agho, M.O., Abdullahi, A.L., Uba, A., Dukku, H.U. & Wufem, B.M., 2005. An ethnobotanical survey of Bauchi State herbal plants and their antimicrobial activity. Journal of Ethnopharmacology 99(1): 1–4.

Addo-Fordjour, P., Anning, A.K., Belford, E.J.D. & Akonnor, D., 2008. Diversity and conservation of medicinal plants in the Bomaa community of the Brong Ahafo region, Ghana. Journal of Medicinal Plants Research 2(9): 226–233.

Addo-Fordjour, P., Obeng, S., Anning, A.K. & Addo, M.G., 2009. Floristic composition, structure and natural regeneration in a moist semi-deciduous forest following anthropogenic disturbances and plant invasion. International Journal of Biodiversity and Conservation 1(2): 21–37.

Adebajo, A.C., Aladesanmi, A.J. & Oloke, K., 1991. Antimicrobial activity of Laportea aestuans. Fitoterapia 62: 504–505.

Adefris, T., Getinet, A. & Tesfaye, G., 1992. Linseed breeding in Ethiopia. In: Oilseeds research and development in Ethiopia. Proceedings of the First National Oilseeds Workshop, 3–5 December, 1991. IAR, Addis Ababa, Ethiopia. pp. 41–50.

Aderogba, M.A., Okoh, E.K. & Idowu, T.O., 2005. Evaluation of the antioxidant activity of the secondary metabolites from Piliostigma reticulatum (DC.) Hochst. Journal of Biological Sciences 5(2): 239–242.

Aderogba, M.A., Okoh, E.K., Adelanwa, T.A. & Obuotor, E.M., 2004. Antioxidant properties of the Nigerian Piliostigma species. Journal of Biological Sciences 4(4): 501–503.

Aderogba, M.A., Okoh, E.K., Okeke, I.N., Olajide, A.O. & Ogundaini, A.O., 2006. Antimicrobial and anti-inflammatory effects of Piliostigma reticulatum leaf extract. International Journal of Pharmacology 2(1): 70–74.

Adesope, A.A.A., Ajala, O.O., Idumah, F.O. & Koyejo, O.A., 2006. Evaluation of the fibre characteristics of Ficus exasperata Valh. In: Popoola, L. (Editor). Forestry at crossroads in Nigeria. Proceedings of the 31st Annual Conference of the Forestry Association of Nigeria, 20–25 November 2006, Makurdi, Benue State, Nigeria. Forestry Association of Nigeria, Ibadan, Nigeria. pp. 25–29.

Adewunmi, C.O. & Sofowora, E.A., 1980. Preliminary screening of some plant extracts for molluscicidal activity. Planta Medica 39: 57–65.

Adjanohoun, E.J., 1962. Etude phytosociologique des savanes de basse Cote d'Ivoire (Savanes lagunaires). Vegetatio Acta Geobotanica 11(1–2): 1–38.

Adjanohoun, E.J. & Aké Assi, L., 1979. Contribution au recensement des plantes médicinales de Côte d'Ivoire. Centre National de Floristique, Abidjan, Côte d'Ivoire. 358 pp.

Adjanohoun, E.J., Aké Assi, L., Floret, J.J., Guinko, S., Koumaré, M., Ahyi, M.R.A. & Raynal, J., 1979. Médecine traditionelle et pharmacopée - Contribution aux études ethnobotaniques et floristiques au Mali. Agence de Coopération Culturelle et Technique, Paris, France. 291 pp.

Adjanohoun, E.J., Abel, A., Aké Assi, L., Brown, D., Chetty, K.S., Chong-Seng, L., Eymé, J., Friedman, F., Gassita, J.N., Goudoté, E.N., Govinden, P., Keita, A., Koudogbo, B., Lai-Lam, G., Landreau, D., Lionnet, G. & Soopramanien, A., 1983a. Médecine traditionelle et pharmacopée - Contribution aux études ethnobotaniques et floristiques aux Seychelles. Agence de Coopération Culturelle et Technique, Paris, France. 170 pp.

Adjanohoun, E.J., Aké Assi, L., Eymé, J., Gassita, J.N., Goudoté, E., Guého, J., Ip, F.S.L., Jackaria, D., Kalachand, S.K.K., Keita, A., Koudogbo, B., Landreau, D., Owadally, A.W. & Soopramanien, A., 1983b. Médecine traditionelle et pharmacopée - Contribution aux études ethnobotaniques et floristiques à Maurice (Iles Maurice et Rodrigues). Agence de Coopération Culturelle et Technique, Paris, France. 216 pp.

Adjanohoun, E.J., Ahyi, A.M.R., Aké Assi, L., Baniakina, J., Chibon, P., Cusset, G., Doulou, V., Enzanza, A., Eymé, J., Goudoté, E., Keita, A., Mbemba, C., Mollet, J., Moutsamboté, J.-M., Mpati, J. & Sita, P. (Editors), 1988. Médecine traditionnelle et pharmacopée - Contribution aux études ethnobotaniques et floristiques en République Populaire du Congo. Agence de Coopération Culturelle et Technique, Paris, France. 606 pp.

Adjanohoun, E.J., Adjakidjè, V., Ahyi, M.R.A., Aké Assi, L., Akoègninou, A., d'Almeida, J., Apovo, F., Boukef, K., Chadare, M., Cusset, G., Dramane, K., Eyme, J., Gassita, J.N., Gbaguidi, N., Goudote, E., Guinko, S., Houngnon, P., Lo, I., Keita, A., Kiniffo, H.V., Kone-Bamba, D., Musampa Nseyya, A., Saadou, M., Sodogandji, T., De Souza, S., Tchabi, A., Zinsou Dossa, C. & Zohoun, T., 1989. Contribution aux études ethnobotaniques et floristiques en République Populaire du Bénin. Agence de Coopération Culturelle et Technique, Paris, France. 895 pp.

Adjanohoun, E.J., Ahiyi, M.R.A., Aké Assi, L., Dramane, K., Elewude, J.A., Fadoju, S.U., Gbile, Z.O., Goudote, E., Johnson, C.L.A., Keita, A., Morakinyo, O., Ojewole, J.A.O., Olatunji, A.O. & Sofowora, E.A., 1991. Traditional medicine and pharmacopoeia: contribution to ethnobotanical and floristic studies in western Nigeria. OUA/ST & RC, Lagos, Nigeria. 420 pp.

Adriaens, M., 2005. Family medicinal plant gardens in the Rwenzori Region. Marianum Press Ltd., Entebbe, Uganda. 137 pp.

Adugna, W. & Labuschagne, M.T., 2002. Genotype-environment interactions and phenotypic stability analyses of linseed in Ethiopia. Plant Breeding 121(1): 66–71.

Adugna, W. & Labuschagne, M.T., 2003. Association of linseed characters and its variability in different environments. Journal of Agricultural Science 140: 285–296.

Adugna, W. & Labuschagne, M.T., 2004. Diversity analysis in Ethiopian and some exotic collections of linseed. South African Journal of Plant and Soil 21(1): 53–58.

Adugna, W., Labuschagne, M.T. & Hugo, H., 2004. Variability in oil content and fatty acid composition of Ethiopian and introduced cultivars of linseed. Journal of the Science of Food and Agriculture 84: 601–607.

Adugna, W., Viljoen, C.D. & Labuschagne, M.T., 2005. Analysis of genetic diversity in linseed using AFLP markers. SINET: Ethiopian Journal of Science 28(1): 41–50.

AduTutu, M., Afful, Y., Asante-Appiah, K., Lieberman, D., Hall, J.B. & Elvin-Lewis, M., 1979. Chewing stick usage in Southern Ghana. Economic Botany 33(3): 320–328.

Afaq-Husain, S., Saeed, V.A. & Shahid-Husain, S., 1988. Cytological investigations in Abutilon Mill., from Pakistan. Pakistan Journal of Botany 20: 191–199.

Afolayan, T.A. & Ajayi, S.S., 2008. The influence of seasonality on the distribution of large mammals in the Yankari Game Reserve, Nigeria. African Journal of Ecology 18(1): 87–96.

Aganga, A.A., Omphile, U.J. & Mojaditlhogo, N., 2005. Composition and digestibility of indigenous grasses in the Hardveld of Botswana during the dry season. Archivos de Zootecnia 54: 587–598.

Aganga, A.A., Adogla-Bessa, T., Omphile, U.J. & Tshireletso, K., 2000. Significance of browses in the nutrition of Tswana goats. Archivos de Zootecnia 49(188): 469–480.

Agbedahunsi, J.M., Adesina, S.K. & Elujoba, A.A., 1990. Fermentation of Furcraea selloa leaf for steroidal sapogenins. Fitoterapia 61(4): 364–366.

Agnew, A.D.Q., 1974. Upland Kenya wild flowers: a flora of the ferns and herbaceous flowering plants of upland Kenya. Oxford University Press, London, United Kingdom. 827 pp.

Aguiba, M.M., 2005. Virus-resistant GM abaca seen to raise yield to 3 MT/ha. Manila Bulletin, 3 July 2005. [Internet] <http://www.highbeam.com>. Accessed September 2010.

Aguilar, N.O., 1992. Imperata cylindrica (L.) Raeuschel. In: 't Mannetje, L. & Jones, R.M. (Editors). Plant Resources of South-East Asia No 4. Forages. Pudoc Scientific Publishers, Wageningen, Netherlands. pp. 140–142.

Aguilar, N.O., 2001a. Cissus L. In: van Valkenburg, J.L.C.H. & Bunyapraphatsara, N. (Editors). Plant Resources of South-East Asia No 12(2). Medicinal and poisonous plants 2. Backhuys Publishers, Leiden, Netherlands. pp. 155–159.

Aguilar, N.O., 2001b. Triumfetta bartramia L. In: van Valkenburg, J.L.C.H. & Bunyapraphatsara, N. (Editors). Plant Resources of South-East Asia No 12(2): Medicinal and poisonous plants 2. Backhuys Publishers, Leiden, Netherlands. pp. 562–564.

Aguilar, N.O., Jansen, P.C.M. & Brink, M., 2003. Abroma augusta (L.) L.f. In: Brink, M. & Escobin, R.P. (Editors). Plant Resources of South-East Asia No 17. Fibre plants. Backhuys Publishers, Leiden, Netherlands. pp. 59–62.

Aguwa, C.N. & Mittal, G.C., 1983. Abortifacient effects of the roots of Momordica angustisepala. Journal of Ethnopharmacology 7(2): 169–173.

Ahmad, S. & Faruquzzaman, A.K.M., 2000. Field evaluation of kenaf, mesta, and related genera for their reaction to spiral borer. Tropical Agriculture 77: 232–235.

Ahn, P., 1961. Regrowth and swamp vegetation in the western forest areas of Ghana. Journal of the West African Science Association 4: 163–173.

Airy Shaw, H.K., 1951. On the Dioncophyllaceae, a remarkable new family of flowering plants. Kew Bulletin 1951: 327–347.

Aiyedun, K.D. & Oyerinde, S.O., 1998. Traditional architecture among rural communities in Niger State: an ethnoarchaeological study. Nyame Akuma 49: 43–54.

Aiyeloja, A.A. & Ajewole, O.I., 2006. Non-timber forest products' marketing in Nigeria: a case study of Osun state. Educational Research and Reviews 1(2): 52–58.

Ajayi, A.O., 2008. Antimicrobial nature and use of some medicinal plants in Nigeria. African Journal of Biotechnology 7(5): 595–599.

Akah, P.A., Orisakwe, O.E., Gamaniel, K.S. & Shittu, A., 1998. Evaluation of Nigerian traditional medicines 2: effects of some Nigerian folk remedies on peptic ulcer. Journal of Ethnopharmacology 62(2): 123–127.

Aké Assi, L., 1990. Utilisation de diverses espèces de Ficus (Moraceae) dans la pharmacopée traditionelle Africaine en Côte d'Ivoire. In: Ihlenfeldt, H.D. (Editor). Proceedings of the 12th plenary meeting of AETFAT, Hamburg, September 4–10, 1988. Mitteilungen aus dem Institut für Allgemeine Botanik Hamburg 23b: 1039–1046.

Akhtar, M.S., Khan, S., Bashir, S. & Salman, M., 2009. Effect of Lodoicea sechellarum Labill (sea coconut) fruit on blood glucose and lipid profile in type 2 diabetic and normal human volunteers. Diabetologia Croatica 38(4): 87–93.

Akindahunsi, A.A. & Olallleye, M.T., 2003. Toxicological investigation of aqueous-methanolic extract of the calyces of Hibiscus sabdariffa L. Journal of Ethnopharmacology 89: 161–164.

Akin-Osanaiye, B.C., Agbaji, A.S., Agbaji, E.B. & Abdulkadir, O.M., 2009. Proximate composition and the functional properties of defatted seed and protein isolates of kargo (Piliostigma reticulatum) seed. African Journal of Food, Agriculture, Nutrition and Development 6: 1365–1377.

Akinpelu, D. & Obuotor, E.M., 2000. Antibacterial activity of Piliostigma thonningii stem bark. Fitoterapia 71(4): 442–443.

Akobundu, I.O. & Agyakwa, C.G., 1998. A handbook of West African weeds. International Institute of Tropical Agriculture, Ibadan, Nigeria. 564 pp.

Akoègninou, A., van der Burg, W.J. & van der Maesen, L.J.G. (Editors), 2006. Flore analytique du Bénin. Backhuys Publishers, Leiden, Netherlands. 1034 pp.

Akoroda, M.O., 1988. Cultivation of jute (Corchorus olitorius) for edible leaf in Nigeria. Tropical Agriculture 65(4): 297–299.

Akpan, G.A., 2000. Cytogenetic characteristics and the breeding system in six Hibiscus species. Theoretical and Applied Genetics 100(2): 315–318.

Akuodor, G.C., Usman, M.I., Ibrahim, J.A., Chilaka, K.C., Akpan, J.L., Dzarma, S., Muazzam, I. & Osunkwo, U.A., 2011. Anti-nociceptive, anti-inflammatory and antipyretic effects of the methanolic extract of Bombax buonopozense leaves in rats and mice. African Journal of Biotechnology 10(16): 3191–3196.

Al Fatimi, M., Wurster, M., Schroder, G. & Lindequist, U., 2007. Antioxidant, antimicrobial and cytotoxic activities of selected medicinal plants from Yemen. Journal of Ethnopharmacology 111(3): 657–666.

Alam, M.S., Chopra, N., Ali, M. & Niwa, M., 1996. Oleanen and stigmasterol derivatives from Ambroma augusta. Phytochemistry 41(4): 1197–1200.

Alexandre, D.Y., 1980. Caractère saisonnier de la fructification dans une forêt hygrophile de Côte d'Ivoire. Revue d'Ecologie la Terre et la Vie 34: 335–359.

Aliyu, R., Okoye, Z.S.C. & Shier, W.T., 1995. The hepatoprotective cytochrome P-450 enzyme inhibitor isolated from the Nigerian medicinal plant Cochlospermum planchonii is a zinc salt. Journal of Ethnopharmacology 48(2): 89–97.

Allegria, J., Hermans, J.G. & Minnick, G., 1986. Systèmes de sondage pour déterminer la quantité en bois de chauffe des Combretacées dans la forêt classée de Guesselbodi, Niger. Ministère de l'Hydraulique et de l'Environnement, Niamey, Niger. 37 p.

Allen, O.N. & Allen, E.K., 1981. The Leguminosae: a source book of characteristics, uses and nodulation. MacMillan, London, United Kingdom. 812 pp.

Alshammary, S.F., 2007. Some potential plants of coastal and inland salt affected soils and their relation to soil properties. Asian Journal of Plant Sciences 6(5): 821–826.

Alvarado, C.R., Alvarado, C.A. & Mendoza, O.O., 2002. Ceiba pentandra (L.) Gaertn. In: Vozzo, J.A. (Editor). Tropical tree seed manual. USDA, Forest Service Publication, s.l., Washington DC, United States. pp. 394–396.

Alves, A.C., Cruz Costa, M.A. & Ferreira, M.A., 1973. Some binaphthaquinones from Diospyros species. Anais da Faculdade de Farmacia do Porto 33: 5–19.

Al-Yahya, M.A., Tariq, M., Parmart, N.S. & Ageel, A.M., 1987. Pharmacological investigations of Hibiscus micranthus Linn., a febrifuge used in Saudi Arabian folk medicine. Phytotherapy Research 1(2): 73–75.

Amankwatia, Y.O., 1981. Reproductive biology of kenaf (Hibiscus cannabinus L.). Conference proceedings, Accra, Ghana. 86 pp.

Amanor, K.S., 1991. Managing the fallow: weeding technology and environmental knowledge in the Krobo District of Ghana. Agriculture and Human Values 8(1–2): 5–13.

Amarajeewa, B.W.R.C., Mudalige, A.P. & Kumar, V., 2007. Chemistry and mosquito larvicidal activity of Gnidia glauca. Proceedings of the Peradeniya University Research Sessions 12(1): 101–102.

Amonkan, K.A., Kati-Coulibaly, S., Kouadio Yatti, J. & Offoumou, A.M., 2005. Comparaison du potentiel diurétique et électrolytique de l'extrait aqueux de Ficus exasperata (Moraceae) et du furosémide chez le rat. Le Pharmacien d'Afrique 186: 15–22.

Anaga, A.O. & Oparah, N.Q., 2009. Investigation of the methanol root extract of Cochlospermum planchonii for pharmacological activities in vitro and in vivo. Pharmaceutical Biology 47(11): 1027–1034.

Anandjiwala, R.D., Hunter, L., Kozlowski, R.M. & Zaikov, G.E., 2007. Textiles for sustainable development. Nova Science Publishers, New York, United States. 435 pp.

Anderson, J., Cowlishaw, G. & Rowcliffe, J.M., 2007. Effects of forest fragmentation on the abundance of Colobus angolensis palliatus in Kenya's coastal forests. International Journal of Primatology 28(3): 637–655.

Anderson, D.M.W., Howlett, J.F. & McNab, C.G.A., 1987. The hydroxyproline content of gum exudates from several plant genera. Phytochemistry 26(1): 309–313.

Andersson, L., 1981. Revision of the Thalia geniculata complex (Marantaceae). Nordic Journal of Botany 1(1): 48–56.

Andersson, L. & Chase, M.W., 2001. Phylogeny and classification of Marantaceae. Botanical Journal of the Linnean Society 135(3): 275–287.

Andre, W. & Beaver, K., 2006. Traditional uses of native plants. Kapisen 5: 3.

Andrews, F.W., 1952. The flowering plants of the Anglo-Egyptian Sudan, Volume 2. Buncle, Arbroath, United Kingdom. 485 pp.

Angelini, L.G., Macchia, M., Ceccarine, L. & Bonari, E., 1998. Screening of kenaf (Hibiscus cannabinus L.) genotypes for low temperature requirements during germination and evaluation of feasibility of seed production in Italy. Field Crops Research 59(1): 73–79.

Annan, K. & Houghton, P.J., 2008. Antibacterial, antioxidant and fibroblast growth stimulation of aqueous extracts of Ficus asperifolia Miq. and Gossypium arboreum L., wound-healing plants of Ghana. Journal of Ethnopharmacology 119: 141–144.

Anokbonggo, W.W., Odoi-Adome, R. & Oluju, P.M., 1990. Traditional methods in management of diarrhoeal diseases in Uganda. Bulletin of the World Health Organization 66(3): 359–363.

Anonymous, 1921. Nigerian grasses for paper making. Bulletin of the Imperial Institute, London 19: 271–282.

Anonymous, 1937. Lalang grass (Imperata arundinacea) as a papermaking material. Bulletin of the Imperial Institute 35: 311–316.

Anonymous, 1958. Annual Report of the West African Cocoa Research Institute, 1956–57. West African Cocoa Research Institute, Accra, Ghana. 90 pp.

Anonymous, 2003. Stratégie de conservation et d'utilisation durables de la diversité biologique. Ministère de l'Environnement et des Ressources Forestières, Lomé, Togo. 132 pp.

Anonymous, 2008. The biology of Gossypium hirsutum L. and Gossypium barbadense L. (cotton). Version 2. [Internet] Australian Government, Department of Health and Ageing, Office of the Gene Technology Regulator <http://www.ogtr.gov.au/ internet/ogtr/publishing.nsf/content/cotton-3/$FILE/ biologycotton08.pdf>. Accessed September 2011.

Anttila, L.S., Alakoski-Johansson, G.M. & Johansson, S.G., 1993. Browse preference of Orma livestock and chemical composition of Prosopis juliflora and nine indigenous woody species in Bura, Eastern Kenya. Forestry in irrigation schemes with special reference to Kenya. East African Agricultural and Forestry Journal 58, Special Issue: 83–90.

Apema, A.K., 1995. Synthèse phytosociologique des végétations aquatique et semi-aquatique du Zaïre. Thèse de Doctorat, Institut de Botanique, Laboratoire de Botanique systématique et de Phytosociologie, ULB, Bruxelles, Belgium. 723 pp.

Apetorgbor, M.M., Siaw, D.E.K.A. & Gyimah, A., 2003. Decline of Ceiba pentandra seedlings, a tropical timber species, in nurseries and plantations. Ghana Journal of Forestry 11(2): 51–62.

APG III, 2009. An update of the Angiosperm Phylogeny Group classification for the orders and families of flowering plants: APG III. Botanical Journal of the Linnean Society 161: 105–121.

Apori, S.O., Castro, F.B., Shand, W.J. & Ørskov, E.R., 1998. Chemical composition, in sacco degradation and in vitro gas production of some Ghanaian browse plants. Animal Feed Science and Technology 76 (1–2): 129–137.

Appiah, J.K., 2008. Some physical properties and drying characteristics of Broussonetia papyrifera from Afram Headwaters Forest Reserve in Ghana. Research findings presented at a colloquium held on 28th August 2008 at FORIG, Kumasi, Ghana.

Applequist, W.L., 2009. Two new species of Dombeya (Malvaceae) from Madagascar. Novon 19(3): 289–294.

AQUIS, 2010. Diospyros spp. Australian quarantine and inspection services. Department of Agriculture, Fisheries and Forestry, Canberra, Australis. [Internet] <http://www.aqis.gov.au/icon32/asp/ex_casecontent.asp?intNodeId=8308795&intCommodityId=23914&Types=none&WhichQuery=Go+to+full+text&intSearch=1&LogSessionID=0>. Accessed April 2010.

Arantes, A.A., Prado, J. & Ranal, M.A., 2007. Macrothelypteris e Thelypteris subg. Cyclosorus (Thelypteridaceae) da Estação Ecológica do Panga, Uberlândia, Minas Gerais, Brazil. Revista Brazileira de Botanica 30(3): 411–420.

Arbonnier, M., 2000. Arbres, arbustes et lianes des zones sèches d'Afrique de l'Ouest. CIRAD, MNHN, UICN. 541 pp.

Arbonnier, M., 2002. Arbres, arbustes et lianes des zones sèches d'Afrique de l'Ouest. CIRAD, MNHN, UICN. 573 pp.

Arbonnier, M., 2004. Trees, shrubs and lianas of West African dry zones. CIRAD, Margraf Publishers Gmbh, MNHN, Paris, France. 573 pp.

Aregawi, T., Melaku, S. & Nigatu, L., 2008. Management and utilization of browse species as livestock feed in semi-arid district of North Ethiopia. [Internet] Livestock Research for Rural Development 20(6), article 86. 8 pp. <http://www.lrrd.org/ lrrd20/6/ areg20086.htm>. Accessed November 2010.

Arenas, P. & Scarpa, G.F., 2003. The consumption of Typha domingensis Pers. (Typhaceae) pollen among the ethnic groups of the Gran Chaco, South America. Economic Botany 57(3): 181–188.

Arènes, J., 1959. Sterculiacées (Sterculiaceae). Flore de Madagascar et des Comores (plantes vasculaires), famille 131. Firmin-Didot et cie., Paris, France. 537 pp.

Armecin, R.B., Seco, M.H.P., Caintic, P.S. & Milleza, E.J.M., 2005. Effect of leguminous cover crops on the growth and yield of abaca (Musa textilis Nee). Industrial Crops and Products 21(3): 317–323.

Arnold, H.J. & Gulumian, M., 1984. Pharmacopoeia of traditional medicine in Venda. Journal of Ethnopharmacology 12: 35–74.

Asase, A. & Oppong-Mensah, G., 2009. Traditional antimalarial phytotherapy remedies in herbal markets in southern Ghana. Journal of Ethnopharmacology 126(3): 492–499.

Ashton, D.H., 1975. The root and shoot development of Eucalyptus regnans F. Muell. Australian Journal of Botany 23(6): 867–887.

Association Flore Réunion, 2001. Encyclopédie on line de la flore de la Réunion. [Internet] <http://www.flore reunion.com/frame.html>. Accessed October 2009.

Asuzu, I.U. & Onu, U.O., 1994. Anthelmintic activity of the ethanolic extract of Piliostigma thonningii bark in Ascaridia galli infected chickens. Fitoterapia 65(4): 291–297.

Asuzu, I.U., Gray, A.I. & Waterman, P.G., 1999. The anthelmintic activity of D-3-O methylchiroinositol isolated from Piliostigma thonningii stem bark. Fitoterapia 70(1): 77–79.

Atawodi, S.E., Bulus, T., Ibrahim, S., Ameh, D.A., Nok, A.J., Mamman, M. & Galadima, M., 2003. In vitro trypanocidal effect of methanolic extract of some Nigerian savannah plants. African Journal of Biotechnology 2(9): 317–312.

Atindehou, K.K., Koné, M., Terreaux, C., Traoré, D., Hostettmann, K. & Dosso, M., 2002. Evaluation of the antimicrobial potential of medicinal plants from the Ivory Coast. Phytotherapy Research 16(5): 497–502.

Attah, A., 2005. Africa's production and trade of TP, present status and outlook. Paper presented at the ITTO/FAO International Conference on Tropical Plywood, 26–28 September 2005, Beijing, China.

Aubréville, A., 1936. La flore forestière de la Côte d'Ivoire. Tome 3. Larose, Paris, France. 285 pp.

Aubréville, A., 1950. Flore forestière soudano-guinéenne. Société d'Editions Géographiques, Maritimes et Coloniales, Paris, France. 533 pp.

Aubréville, A., 1959a. La flore forestière de la Côte d'Ivoire. Deuxième édition révisée. Tome deuxième. Publication No 15. Centre Technique Forestier Tropical, Nogent-sur-Marne, France. 341 pp.

Aubréville, A., 1959b. La flore forestière de la Côte d'Ivoire. Deuxième édition révisée. Tome premier. Publication No 15. Centre Technique Forestier Tropical, Nogent-sur-Marne, France. 369 pp.

Aubréville, A., 1959c. La flore forestière de la Côte d'Ivoire. Deuxième édition révisée. Tome troisième. Publication No 15. Centre Technique Forestier Tropical, Nogent-sur-Marne, France. 334 pp.

Aubréville, A., 1970. Légumineuses - Césalpinioidées (Leguminosae - Caesalpinioideae). Flore du Cameroun. Volume 9. Muséum National d'Histoire Naturelle, Paris, France. 339 pp.

Aubrey, A., 2004. Phoenix reclinata Jacq. [Internet] South African National Biodiversity Institute, Kirstenbosch, South Africa. <http://www.plantzafrica.com/ plantnop/ phoenixrec.htm>. Accessed February 2011.

Auquier, P. & Renard, R., 1975. Chromosome numbers of some angiosperms from Rwanda Burundi and Kivu, Zaire. Part 1. Bulletin du Jardin Botanique National de Belgique 45(3–4): 421–445.

Australian National Botanic Gardens, 2001. Thelypteridaceae. [Internet] In: Ferns and fern allies. Australian National Herbarium, Canberra, Australia. <http://www.anbg.gov.au/ fern/aquatic/ thelypteridaceae.html>. Accessed February 2010.

Awe, S. & Omojasola, P.F., 2009. A comparative study of the antibacterial activity of Piliostigma reticulatum bark extract with some antibiotics. Ethnobotanical Leaflets 13: 1197–1204.

Ayantunde, A.A., Hiernaux, P., Briejer, M., Udo, H. & Tabo, R., 2009. Uses of local plant species by agropastoralists in south-western Niger. Ethnobotany Research & Applications 7: 53–66.

Ayeni, A.O. & Duke, W.B., 1985. The influence of rhizome features on subsequent regenerative capacity in speargrass (Imperata cylindrica (L.) Beauv.). Agriculture, Ecosystems and Environment 35: 309–317.

Ayensu, E.S., 1978. Medicinal plants of West Africa. Reference Publication, Michigan. 330 pp.

Ayim, J.S., Dwuma Badu, D., Fiagbe, N.Y., Ateya, A.M., Slatkin, D.J., Knapp, J.E. & Schiff, P.L., 1977. Constituents of West African medicinal plants. 21. Tiliafunimine, a new imino bisbenzylisoquinoline alkaloid from Tiliacora funifera. Lloydia 40(6): 561–565.

Ayinde, B.A., Omogbai, E.K. & Amaechina, F.C., 2007. Pharmacognosy and hypotensive evaluation of Ficus exasperata Vahl (Moraceae) leaf. Acta Poloniae Pharmaceutica - Drug Reserach 64(6): 543–546.

Ayisire, B.E., Akinro, L.A. & Amoo, S.O., 2009. Seed germination and in vitro propagation of Piliostigma thonningii – an important medicinal plant. African Journal of Biotechnology 8(3): 401–404.

Ayoub, H.S.M., 1985. Flavanol molluscicides from the Sudan acacias. Pharmaceutical Biology 23(2): 87–90.

AZT, 2011. A resource for landscape professionals. [Internet] <http://www.aridzonetrees.com/ Home%20Page.htm>. Accessed January 2011.

Babajide, O.J., Babajide, O.O., Daramola, A.O. & Mabusela, W.T., 2008. Flavonols and an oxychromonol from Piliostigma reticulatum. Phytochemistry 69(11): 2245–2250.

Babatunde, F.E., 2003. Intercrop productivity of roselle in Nigeria. Journal of Tropical Crop Science and Production 11(1): 102–104.

Babu, B.H., Jayram, H.N., Nair, M.G., Ajaikumar, K.B. & Padikkala, J., 2003. Free radical scavenging, antitumor and anticarcinogenic activity of gossypin. Journal of Experimental & Clinical Cancer Research 22 (4): 581–589.

Bachir, O. & Abdellah, B., 2006. Chromosome numbers of the 59 species of Eucalyptus l'Herit (Myrtaceae). Caryologia 59(3): 207–212.

Backer, C.A. & Bakhuizen van den Brink Jr, R.C., 1968. Flora of Java. Volume 3. Wolters-Noordhoff, Groningen, Netherlands. 761 pp.

Backius, I., 1989. Flarks in the Maloti, Llesotho. Geografiska Annaler, Series A, Physical Geography 71(1/2): 105–111.

Baert, J. & Raemaekers, R.H., 2001. Urena. In: Raemaekers, R.H. (Editor). Crop production in tropical Africa. DGIC (Directorate General for International Co-operation), Ministry of Foreign Affairs, External Trade and International Co-operation, Brussels, Belgium. pp. 1083–1086.

Baerts, M. & Lehmann, J., 1989. Guérisseurs et plantes médicinales de la région des crêtes Zaïre-Nil au Burundi. Annales Sciences Economiques Vol. 18. Musée Royal de l'Afrique Centrale, Tervuren, Belgium. 214 pp.

Baerts, M. & Lehmann, J., 2006. Lannea schimperi. [Internet]. Prelude Medicinal Plants Database. Metafro-Infosys, Royal Museum for Central Africa, Tervuren, Belgium <http://www.metafro.be/prelude>. Accessed April 2009.

Baerts, M. & Lehmann, J., 2009. Girardinia bullosa. [Internet] Prelude Medicinal Plants Database. Metafro-Infosys, Royal Museum for Central Africa, Tervuren, Belgium <http://www.metafro.be/prelude>. Accessed May 2009.

Baerts, M. & Lehmann, J., 2011. Urena lobata. [Internet] Prelude Medicinal Plants Database. Metafro-Infosys, Royal Museum for Central Africa, Tervuren, Belgium <http://www.metafro.be/prelude>. Accessed August 2011.

Bafor, E.E., Omogbai, E.K. & Ozolua, R.I., 2009. Evaluation of the uterotonic activity of the aqueous leaf extract of Ficus exasperata Vahl (Moraceae). Research Journal of medicinal Plants 3(2): 34–40.

Bafor, E.E. & Igbinuwen, O., 2009. Acute toxicity studies of the leaf extract of Ficus exasperata on haematological parameters, body weight and body temperature. Journal of Ethnopharmacology 123(2): 302–307.

Bahuchet, S., 1993. La rencontre des agriculteurs: les Pygmées parmi les peuples d'Afrique centrale. Peeters, Louvain, Belgium & Société d'Etudes Linguistiques et Anthropologiques de France (SELAF), Paris, France. 173 pp.

Bailey, L.H., 1947. Pandanus. In: Bailey, L.H. (Editor). The standard cyclopedia of horticulture. 3 volumes. The MacMillan Company, New York, United States. pp. 2449–2451.

Bailey, L.H., 1951. Manual of cultivated plants most commonly grown in the continental United States and Canada. MacMillan Publishing Co., New York, United States. 1116 pp.

Bailey, L.H. & Bailey, E.Z., 1976. Hortus third. A concise dictionary of plants cultivated in the United States and Canada. MacMillan Publishing Co., New York, United States. 1290 pp.

Bailly, C., Barrier, C., Clément, J., Goudet, J.P. & Hamel, O., 1982. Les problèmes de la satisfaction des besoins en bois en Afrique tropicale sèche. Bois et Forêts des Tropiques 197: 23–43.

Bajet, N.B. & Magnaye, L.V., 2002. Virus diseases of banana and abaca in the Philippines. PARRFI, Los Baños, Philippines. 82 pp.

Baker, J.G., 1877. Hypoxidaceae. In: Baker, J.G. (Editor). Flora of Mauritius and the Seychelles: a description of the flowering plants and ferns of those islands. L. Reeve & Co., London, United Kingdom. pp. 368–369.

Baker, N.E., 1915. Sansevieria: a monograph of all the known species. Bulletin of Miscellaneous Information Kew 1915(5): 185–261.

Baker, H.G., 1965. The evolution of the cultivated kapok tree: a probable West African product. In: Brokensha, D. (Editor). Ecology and economic development in tropical Africa. Research Series No 9. Institute of International Studies, University of California, Berkeley, United States. pp. 185–216.

Baker, R.G.E. & Boatman, D.J., 1990. Some effects of nitrogen, phosphorus, potassium and carbon dioxide concentration on the morphology and vegetative reproduction of Sphagnum cuspidatum Ehrh. New Phytologist 116(4): 605–611.

Baker, R.T. & Smith, H.G., 1920. A research on the eucalypts especially in regard to their essential oils. [Internet] Authority of the Government of the State of New South Wales, Sydney, Australia. <http://chestofbooks.com/ health/aromatherapy/Eucalyptus-Essential-Oils/ 161-Eucalyptus-regnans.html>. Accessed May 2009.

Baker, J.G. & Wright, C.H., 1909–1913. Aristolochiaceae. In: Thiselton-Dyer, W.T. (Editor). Flora of tropical Africa. Volume 6(1). Lovell Reeve & Co., London, United Kingdom. pp. 134–143.

Bakuneeta, C., 1997. The chimpanzees of Budongo Forest: a case study. In: Edroma, E., Rosen, N. & Miller, P. (Editors). Conserving the chimpanzees of Uganda: population and habitat viability assessment for Pan troglodytes schweinfurthii. Proceedings of a workshop held in Entebbe, Uganda. pp. 172–179.

Bal, K. E., Bal, Y. & Lallam, A., 2004. Gross morphology and absorption capacity of cell-fibers from the fibrous vascular system of loofah (Luffa cylindrica). Textile Research Journal 74(3): 241–247.

Balakrishnan, N., Bhaskar, V.H., Sangameswaran, B., Panda, A.B., Singh, S., Raj, N.R., Kumar, C.S.S. & Sathish, A., 2008. Wound healing properties of hydroalcoholic extract of Sida (Indian) species. Plant Archives 8(1): 485–487.

Baldwin, J.T. & Speese, B.M., 1957. Flagellaria guineensis Schum. Bulletin of the Torrey Botanical Club 84(2): 90–93.

Balfour, I.B., 1877. Pandaneae. In: Baker, J.G. (Editor). Flora of Mauritius and the Seychelles: a description of the flowering plants and ferns of those islands. L. Reeve & Co., London, United Kingdom. pp. 395–403.

Ball, P.W., Reznicek, A.A. & Murray, D.F. (Editors), 2003. Cyperaceae. [Internet] Flora of North America. Volume 23. <http://www.efloras.org/ florataxon.aspx?flora_id=1&taxon_id=10246>. Accessed June 2011.

Balogun, A.M. & Fetuga, B.L., 1988. Tannin, phytin and oxalate contents of some wild underutilized crop-seeds in Nigeria. Food Chemistry 30(1): 37–43.

Balu Perumal, 2001a. Abutilon Miller. In: van Valkenburg, J.L.C.H. & Bunyapraphatsara, N. (Editors). Plant Resources of South-East Asia No 12(2): Medicinal and poisonous plants 2. Backhuys Publishers, Leiden, Netherlands. pp. 29–31.

Balu Perumal, 2001b. Sida L. In: van Valkenburg, J.L.C.H. & Bunyapraphatsara, N. (Editors). Plant Resources of South-East Asia No 12(2): Medicinal and poisonous plants 2. Backhuys Publishers, Leiden, Netherlands. pp. 496–500.

Banderembako, F. & Ntitangirageza, T., 1978. La médecine populaire au Burundi: quelques plantes médicinales. Que vous en semble 35. 20 pp.

Bandopadhyay, A., Ghosh, S.N. & Das, A.K., 2003. In-vitro evaluation of some plant extracts for antimicrobial activity. Journal of Mycopathological Research 41(2): 205–209.

Banso, A. & Adeyemo, S., 2004. Phytochemical screening and antimicrobial assessment of Abutilon mauritianum, Bacopa monnifera and Datura stramonium. Biokemistri 18(1): 39–44.

Banuelos, G.S., 1996. Managing high levels of boron and selenium with trace element accumulator crops. Journal of Environmental Science and Health. Part A. Environmental Science and Engineering and Toxic and Hazardous Substance Control 31(5): 1179–1196.

Banzouzi, J.T., Prost, A., Rajemiarimiraho, M. & Ongoka, P., 2008. Traditional uses of the African Millettia species (Fabaceae). International Journal of Botany 4(4): 406–420.

Bapuji, J.L. & Ratnam, S.V., 2009. Traditional uses of some medicinal plants by tribals of Gangaraju Madugula Mandal of Visakhapatnam District, Andhra Pradesh. Ethnobotanical Leaflets 13: 388–398.

Barakat, S.E.M., Adam, S.E.I., Maglad, M.A. & Wasfi, I.A., 1985. Effects of Cissus quadrangularis on goats and sheep in Sudan. Revue d'Elevage et de Médecine Vétérinaire des Pays Tropicaux 38(2): 185–819.

Barakoti, T.P. & Shrestha, K.P., 2008. Commercial utilization of allo (Girardinia diversifolia) by the Rais of Sankhuwasabha for income generation. Banko Janakari 18(1): 18–24.

Barbier, C., 1985. Further notes on Livistona carinensis in Somalia. Principes 29(4): 151–155.

Barbosa-Filho, J.M., Da-Cunha, E.V.L. & Gray, A.I., 2000. Alkaloids of the Menispermaceae. The Alkaloids 54: 1–190.

Barclay, A.S. & Earle, F.R., 1974. Chemical analyses of seeds III: oil and protein content of 1253 species. Economic Botany 28(2): 178–236.

Barreto, A.C.H., Rosa, D.S., Fechine, P.B.A. & Mazzetto, S.E., 2011. Properties of sisal fibers treated by alkali solution and their application into cardanol-based biocomposites. Composites Part A 42: 492–500.

Barrow, S.C., 1998. A monograph of Phoenix L. (Palmae: Coryphoideae). Kew Bulletin 53(3): 513–575.

Basumatary, S.K., Ahmed, M. & Deka, S.P., 2004. Some medicinal plant leaves used by Boro (tribal) people of Goalpara district, Assam. Natural Product Radiance 3(2): 88–90.

Batawila, K., Akpavi, S., Wala, K., Kanda, M., Vodouhe, R. & Akpagana, K., 2007. Diversité et gestion des legumes de cueillette au Togo. [Internet] African Journal of Food Agriculture Nutrition and Development 7(3). <http://www.bioline.org.br/ pdf?nd07025>. Accessed June 2009.

Baum, D.A. & Ogunima, K., 1994. A review of chromosome numbers in Bombacaceae with new counts for Adansonia. Taxon 43(1): 11–20.

Baumer, M.C., 1975. Catalogue des plantes utiles du Kordofan (République du Soudan) particulièrement du point de vue pastoral. Journal d'Agriculture Tropicale et de Botanique Appliquée 22: 105.

Baumer, M., 1983. Notes on trees and shrubs in arid and semi-arid regions. Ecological management of arid and semi-arid rangelands in Africa and the Near and Middle East (EMASAR) - Phase 2. FAO, Rome, Italy. 270 pp.

Bayer, C., 2007. Peridiscaceae. In: Kubitzki, K. (Editor). The families and genera of vascular plants. Vol. 9. Flowering plants - Eudicots. Springer-Verlag, Berlin, Heidelberg, Germany. pp. 297–300.

Bazara, M., Guarino, L., Miller, A. & Obadi, N., 1990. Observations on an endangered fan palm in Arabia. Edinburgh Journal of Botany 47(3): 375–379.

Bazié, G., 2007. Essai de germination et de croissance de Phoenix dactylifera L. et de Grewia lasiodiscus K. Schum. Rapport de stage, Diplôme de Controleur des Eaux et Forêts, Ecole Nationale des Eaux et Forêts de Dindérésso, Bobo Dioulasso, Burkina Faso. 37 pp.

Bazira, M.H., Bekunda, M.A. & Tenywa, J.S., 1997. Decomposition characteristics of mixed grass and banana residues and their effects on banana plant performance. African Crop Science Conference Proceedings 3: 421–428.

Becker, M. & Johnson, D.E., 1999. The role of legume fallows in intensified upland ricebased systems of West Africa. Nutrient Cycling in Agroecosystems 53: 71–81.

Bedford, G.O., 1980. Biology, ecology, and control of palm rhinoceros beetles. Annual Review of Entomology 25: 309–339.

Bedigian, D., 2003. Evolution of sesame revisited: domestication, diversity and prospects. Genetic Resources and Crop Evolution 50: 779–787.

Bedigian, D., 2004. Slimy leaves and oily seeds: distribution and use of wild relatives of sesame in Africa. Economic Botany 58 (Suppl. S): S3–S33.

Beentje, H.J., 1989. Bombacaceae. In: Polhill, R.M. (Editor). Flora of Tropical East Africa. A.A. Balkema, Rotterdam, Netherlands. 9 pp.

Beentje, H.J., 1993. Pandanaceae. In: Polhill, R.M. (Editor). Flora of Tropical East Africa. A.A. Balkema, Rotterdam, Netherlands. 9 pp.

Beentje, H.J., 1994a. A monograph of Ravenea (Palmae: Ceroxyloideae). Kew Bulletin 49(4): 623–671.

Beentje, H.J., 1994b. Kenya trees, shrubs and lianas. National Museums of Kenya, Nairobi, Kenya. 722 pp.

Beentje, H.J., 1994c. Ravenea in Madagascar. Principes 38(4): 195–203.

Beentje, H.J., 2000. Compositae (part 1). In: Beentje, H.J. (Editor). Flora of Tropical East Africa. A.A. Balkema, Rotterdam, Netherlands. pp. 1–313.

Beentje, H. & Smith, S., 2001. FTEA and after. Systematics and Geography of Plants 71(2): 265–290.

Bégué, L., 1963. Les Eucalyptus au sud du Sahara. Bois et Forêts des Tropiques 91: 11–22.

Begum, D. & Nath, S.C., 2000. Ethnobotanical review of medicinal plants used for skin diseases and related problems in northeastern India. Journal of Herbs, Spices & Medicinal Plants 7(3): 55–93.

Beharrell, M., 2004. Planting, selection and plant establishment in constructed wetlands in a tropical environment. In: Wong, M.H. (Edtor). Wetlands ecosystems in Asia: function and management. Developments in Ecosystems No 1. Elsevier, Amsterdam, the Netherlands. pp. 311–329.

Bein, E., Habte, B., Jaber, A., Birnie, A. & Tengnäs, B., 1996. Useful trees and shrubs in Eritrea: identification, propagation and management for agricultural and pastoral communities. Technical Handbook No 12. Regional Soil Conservation Unit, Nairobi, Kenya. 422 pp.

Bekele-Tesemma, A., 2007. Useful trees and shrubs for Ethiopia: identification, propagation and management for 17 agroclimatic zones. Technical Manual No 6. RELMA in ICRAF Project, Nairobi, Kenya. 552 pp.

Bekele-Tesemma, A., Birnie, A. & Tengnäs, B., 1993. Useful trees and shrubs for Ethiopia: identification, propagation and management for agricultural and pastoral communities. Technical Handbook No 5. Regional Soil Conservation Unit/SIDA, Nairobi, Kenya. 474 pp.

Bekunda, M.A. & Woomer, P.L., 1996. Organic resource management in banana-based cropping systems of the Lake Victoria Basin, Uganda. Agriculture, Ecosystems & Environment 59: 171–180.

Belem, B., Boussim, J.I., Bellefontaine, R. & Guinko, S., 2008. Stimulation du drageonnage de Bombax costatum par blessure des racines au Burkina Faso. Bois et Forêts des Tropiques 295: 71–79.

Benazir, J.A.F., Manimekalai, V., Ravichandran, P., Suganthi, R. & Dinesh, D.C., 2010. Properties of fibres/culm strands from mat sedge – Cyperus pangorei Rottb. BioResources 5(2): 951–967.

Benoit-Vical, F., Valentin, A., Da, B., Dakuyo, Z., Descamps, L. & Mallié, M., 2003. N'Dribala (Cochlospermum planchonii) versus chloroquine for treatment of uncomplicated Plasmodium falciparum malaria. Journal of Ethnopharmacology 89(1): 111–114.

Berg, C.C., 1986. The Ficus species (Moraceae) of Madagascar and the Comoro Islands. Bulletin du Muséum National d'Histoire Naturelle, 4e série, 8, section B, Adansonia (1): 17–55.

Berg, C.C., 1988. New taxa and combinations in Ficus (Moraceae) of Africa. Kew Bulletin 43(1): 77–97.

Berg, C.C., 1991. Moraceae. In: Launert, E. & Pope, G.V. (Editors). Flora Zambesiaca. Volume 9, part 6. Flora Zambesiaca Managing Committee, London, United Kingdom. pp. 13–76.

Berg, C.C., 2003. Broussonetia papyrifera (L.) L'Hér. ex Vent. In: Brink, M. & Escobin, R.P. (Editors). Plant Resources of South-East Asia No 17. Fibre plants. Backhuys Publishers, Leiden, Netherlands. pp. 91–95.

Berg, C.C. & Hijman, M.E.E., 1989. Moraceae. In: Polhill, R.M. (Editor). Flora of Tropical East Africa. A.A. Balkema, Rotterdam, Netherlands. 95 pp.

Berg, C.C., Hijman, M.E.E. & Weerdenburg, J.C.A., 1984. Moraceae. Flore du Gabon. Volume 26. Muséum National d'Histoire Naturelle, Paris, France. 276 pp.

Berg, C.C., Hijman, M.E.E. & Weerdenburg, J.C.A., 1985. Moraceae (incl. Cecropiaceae). Flore du Cameroun. Volume 28. Muséum National d'Histoire Naturelle, Paris, France. 298 pp.

Berhaut, J., 1967. Flore du Sénégal. 2nd edition. Editions Clairafrique, Dakar, Senegal. 485 pp.

Berhaut, J., 1974. Flore illustrée du Sénégal. Dicotylédones. Volume 2. Balanophoracées à Composées. Gouvernement du Sénégal, Ministère du Développement Rural et de l'Hydraulique, Direction des Eaux et Forêts, Dakar, Senegal. 695 pp.

Berhaut, J., 1975a. Flore illustrée du Sénégal. Dicotylédones. Volume 3. Connaracées à Euphorbiacées. Gouvernement du Sénégal, Ministère du Développement Rural et de l'Hydraulique, Direction des Eaux et Forêts, Dakar, Senegal. 634 pp.

Berhaut, J., 1975b. Flore illustrée du Sénégal. Dicotylédones. Volume 4. Ficoidées à Légumineuses. Gouvernement du Sénégal, Ministère du Développement Rural et de l'Hydraulique, Direction des Eaux et Forêts, Dakar, Senegal. 625 pp.

Bernhard, A., 1999. Flower structure, development, and systematics in Passifloraceae and in Abatia (Flacourtiaceae). International Journal of Plant Science 160(1): 135–150.

Bernholt, H., Kehlenbeck, K., Gebauer, J. & Buerkert, A., 2009. Plant species richness and diversity in urban and peri-urban gardens of Niamey, Niger. Agroforestery Systems 77:159 –179.

Bertrand, M., 2005. Une démarche agronomique pour accompagner le changement technique. Cas de l'emploi du traitement herbicide dans les systèmes de culture à sorgho repiqué au Nord-Cameroun. PhD Thesis, Paris, France. 376 pp.

Betti, J.L., 2001. Vulnérabilité des plantes utilisées comme antipaludiques dans l'arrondissement de Mintom au sud de la réserve de biosphère du Dja (Cameroun). Systematics and Geography of Plants 71: 661-678.

Betti, J.L., 2004. An ethnobotanical study of medicinal plants among the Baka pygmies in the Dja biosphere reserve, Cameroon. African Study Monographs 25(1): 1–27.

Betti, J.L. & Lejoly, J., 2009. Contribution to the knowledge of medicinal plants of the Dja Biosphere Reserve, Cameroon: plants used for treating jaundice. Journal of Medicinal Plants Research 3(12): 1056–1065.

Bhat, R.B., 1998. Medicinal plants of Transkei (South Africa) for the treatment of digestive tract disorders. Phyton 63(1–2): 51–55.

Bhat, R.V. & Guha, S.R.D., 1952. Indigenous cellulosic raw materials for the production of pulp, paper and board. Part 4. Writing and printing papers from paper mulberry (Broussonetia papyrifera). Indian Forester 78: 93–97.

Bhat, R.V. & Virmani, K.C., 1952. Indigenous cellulosic raw materials for the production of pulp, paper, and board. VII. Writing and printing papers from Phragmites karka. Indian Forester 78: 127–137.

Bhat, R.B., Etejere, E.O. & Oladipo, V.T., 1990. Ethnobotanical studies from Central Nigeria. Economic Botany 44(3): 382–390.

Biagiotti, J., Puglia, D. & Kenny, J.M., 2004. A review on natural fibre-based composites – Part 1: structure, processing and properties of vegetable fibres. Journal of Natural Fibres 1(2): 37–68.

Bigendako-Polygenis, M.J. & Lejoly, J., 1990. La pharmacopée traditionelle au Burundi. In: Ansay M. & Thill, G. (Editors). Pesticides et médicaments en santé animale. pp. 425–442.

Bikoumou, J.S., 1998. Contribution à l'étude de la végétation des sols hydromorphes du site du Lac Télé (Sous-préfecture d'Eéna, Préfecture de la Likouala). Rapport de stage de fin de formation, Université Marien Ngouabi, Brazzaville, Congo. 73 pp.

Billore, S.K., Singh, N., Ram, H.K., Sharma, J.K., Singh, V.P., Nelson, R.M. & Dass, P., 2001. Treatment of a molasses based distillery effluent in a constructed wetland in central India. Water Science & Technology 44(11–12): 441–448.

Bingham, M.H., 1990. An ethno-botanical survey of Senanga West. Senanga West Agricultural Development Area, Department of Agriculture, Republic of Zambia. 27 pp.

Bir, S.S., Cheema, P. & Sidhu, M., 1991. Cytological observations of Scirpus linn. from North India. Cytologia 56(4): 645–652.

Bisanda, E.T.N. & Enock, J., 2003. Review on sisal waste utilisation: challenges and opportunities. Discovery and Innovation 15: 17–27.

Bitariho, R., McNeilage, A., Babaasa, D. & Kasangaki, A., 2002. Harvest impacts of plants from Bwindi Impenetrable National Park, Uganda, by local communities. [Internet] Abstracts of the 16th Annual Meeting of the Society for Conservation Biology, Canterbury, United Kingdom. <https://www.conbio.org/ Activities/Meetings/2002/abstracts/Tuesday/ sruone.cfm>. Accessed September 2010.

Bizimana, N., 1994. Traditional veterinary practice in Africa. Deutsche Gesellschaft fur Technische Zusammmenarbeit (GTZ), Eschborn, Germany. 917 pp.

Blach-Overgaard, A., Svenning, J.-C., Dransfield, J., Greve, M. & Balslev, H., 2010. Determinants of palm species distributions across Africa: the relative roles of climate, non-climatic environmental factors, and spatial constraints. Ecography 33(2): 380–391.

Blay, D., 2004. Dental hygiene and livelihoods: a case of chewing sticks in Ghana. In: Sunderland, T. & Ndoye, O. (Editors). Forest products, livelihoods and conservation: case studies of non-timber forest product systems. Volume 2 Africa. CIFOR, Jakarta, Indonesia. pp. 25–36.

Blomstedt, C., Cameron, J., Whiteman, P. & Chandler, S.F., 1991. Micropropagation of juvenile Eucalyptus regnans (mountain ash). Australian Journal of Botany 39(2): 179–186.

Blundell, M., 1987. Collins guide to wild flowers of East Africa. Collins, London, United Kingdom. 464 pp.

Boeke, S.J., Kossou, D.K., van Huis, A., van Loon, J.J.A. & Dicke, M., 2004. Field trials with plant products to protect stored cowpea against insect damage. International Journal of Pest Management 50(1): 1–9.

Bogdan, A.V., 1977. Tropical pasture and fodder plants (grasses and legumes). Longman, London, United Kingdom. 475 pp.

Bogner, J. & Knecht, M., 1995. A new Cercestis species (Araceae) from the Ivory Coast. Bulletin du Museum National d'Histoire Naturelle, B, Adansonia 16(2–4): 331–335.

Bognon, C., 1991. Notes ethnobotaniques sur la médecine traditionnelle en pays Wé (Côte d'Ivoire) : quelques problèmes méthodologiques. Revue de Médecines et Pharmacopées Africaines 5(1): 55–65.

Böhlke, M., 1997. Potential pharmaceutical value of tropical forest plants of Costa Rica and coastal Ghana. PhD thesis, University of Illinois, College of Pharmacy, Chicago, United States. 264 pp.

Boiteau, P., Boiteau, M. & Allorge-Boiteau, L., 1999. Dictionnaire des noms malgaches de végétaux. 4 Volumes + Index des noms scientifiques avec leurs équivalents malgaches. Editions Alzieu, Grenoble, France.

Bolfrey-Arku, G.E., 2004. Management of the noxious weed speargrass (Imperata cylindrica (L.) Beauv.) in the forest and forest-savanna transition agro-ecological zones of Ghana. M.Phil. Crop

Science thesis, Department of Crop Science, School of Agriculture, University of Cape Coast, Cape Coast, Ghana. 161 pp.

Bolza, E. & Keating, W.G., 1972. African timbers: the properties, uses and characteristics of 700 species. Division of Building Research, CSIRO, Melbourne, Australia. 710 pp.

Bombardelli, E., Morazzoni, P. & Mustich, G., 1995. Extracts of Piliostigma thonningii, the use thereof and formulations containing them. Patent number: EP 0685235. European Patent Office, Munich, Germany.

Bombardelli, E., Cristoni, A., Lolla, A., Morazzoni, P., Mustich, G., Pace, R. & Piretti, M.V., 1994. Chemical and biological characterisation of Piliostigma thonningii polyphenols. Fitoterapia 65(6): 493–501.

Bongers, F., Parren, M.P.E. & Traoré, D. (Editors), 2005. Forest climbing plants of West Africa: diversity, ecology and management. CABI, Wallingford, United Kingdom. 273 pp.

Bonnie, N.E., Hanganu, J. & Griffin, C.R., 1997. Reed harvesting in the Danube Delta, Romania: Is it sustainable? Wildlife Society Bulletin, International Issues and Perspectives in Wildlife Management 25(1): 117–124.

Bonyongo, M.C., Bredenkamp, G.J. & Veenendaal, E., 2000. Floodplain vegetation in the Nxaraga lagoon area, Okavango delta, Botswana. South African Journal of Botany 66: 15–21.

Boon, E. & Ahenkan, A., 2008. Impact of deforestation on medicinal plants in Ghana. GRIN Verlag, Munich, Germany. 44 pp.

Boonkerd, T., Na Songkhla, B. & Thephuttee, W., 1993. Hibiscus sabdariffa L. In: Siemonsma, J.S. & Kasem Piluek (Editors). Plant Resources of South-East Asia No 8. Vegetables. Pudoc Scientific Publishers, Wageningen, Netherlands. pp. 178–180.

Boonman, J.G., 1993. East African grasses and fodders: their ecology and husbandry. Kluwer Academic Publishers, Dordrecht, Netherlands. 343 pp.

Booth, F.E.M. & Wickens, G.E., 1988. Non-timber uses of selected arid zone trees and shrubs in Africa. FAO Conservation Guide No 19. FAO, Rome, Italy. 176 pp.

Booth, T.H., Nix, H.A., Hutchinson, M.F. & Jovanovic, T., 1988. Niche analysis and tree species introduction. Forest Ecology and Management 23: 47–59.

Borchsenius, F. & Suksathan, P., 2005. Nomenclatural synopsis of Marantaceae in Thailand. Taxon 54(8): 1083–1090.

Borota, J., 1991. Tropical forests: some African and Asian case studies of composition and structure. Developments in Agricultural and Managed-Forest Ecology No 22. Elsevier, Amsterdam, Netherlands. 274 pp.

Borris, R.P., Blasko, G. & Cordell, G.A., 1988. Ethnopharmacologic and phytochemical studies of Thymelaeaceae. Journal of Ethnopharmacology 24: 41–91.

Bory, S., Grisoni, M., Duval, M.-F. & Besse, P., 2008. Biodiversity and preservation of vanilla: present state of knowledge. Genetic Resources and Crop Evolution 55(4): 551–571.

Bos, J.J. & Teketay, D., 1997. Dracaenaceae. In: Edwards, S., Mesfin Tadesse, Demissew Sebsebe & Hedberg, I. (Editors). Flora of Ethiopia and Eritrea. Volume 6. Hydrocharitaceae to Arecaceae. The National Herbarium, Addis Ababa University, Addis Ababa, Ethiopia and Department of Systematic Botany, Uppsala University, Uppsala, Sweden. pp. 76–82.

Bosma, R.H. & Bicaba, M.Z., 1997. Effect of addition of leaves from Combretum aculeatum and Leucaena leucocephala on digestion of sorghum stover by sheep and goats. Small Ruminant Research 24(3): 167–173.

Bosser, J., 1987. Tiliacées. In: Bosser, J., Cadet, T., Guého, J. & Marais, W. (Editors). Flore des Mascareignes. Familles 51–62. The Sugar Industry Research Institute, Mauritius, l'Office de la Recherche Scientifique Outre-Mer, Paris, France & Royal Botanic Gardens, Kew, Richmond, United Kingdom. 14 pp.

Bosser, J. & Guého, J., 2003. Pandanaceae. In: Bosser, J., Ferguson, I.K. & Soopramanien, C. (Editors). Flore des Mascareignes. Famille 190. Institut de Recherche Scientifique pour le Développement, Paris, France, Mauritius Sugar Industry Research Institute, Mauritius & Royal Botanic Gardens, Kew, Richmond, United Kingdom. 52 pp.

Bosser, J. & Heine, H., 2000. Convolvulacées. In: Bosser, J., Cadet, T., Guého, J. & Marais, W. (Editors). Flore des Mascareignes. Familles 127–135. The Sugar Industry Research Institute, Mauritius, l'Institut pour le Développement (IRD), Paris, France & Royal Botanic Gardens, Kew, Richmond, United Kingdom. 63 pp.

Boudet, G., 1963. Pâturages et plantes fourragères en République de Côte d'Ivoire. Institut d'Elevage et de Médicine Vétérinaire des Pays Tropicaux, Maisons-Alfort, France. 102 pp.

Boukoungou, E.G. & de Framond, H., 1988. Dynamique du peuplement et évolution de la productivité des formations naturelles en forêt classée de Gonse, Burkina-Faso. Bois et Forêts des Tropiques 218: 63–70.

Boulvert, Y., 1977. Catalogue de la flore de Centrafrique: ecologie sommaire et distribution. Tome 1. Forêts denses et galeries forestières. Texte provisoire. ORSTOM, Bangui, Central African Republic. 465 pp.

Bouquet, A., 1969. Féticheurs et médecines traditionnelles du Congo (Brazzaville). Mémoires ORSTOM No 36. Office de la Recherche Scientifique et Technique Outre-Mer. Paris, France. 282 pp.

Bouquet, A. & Debray, M., 1974. Plantes médicinales de la Côte d'Ivoire. Travaux et Documents No 32. ORSTOM, Paris, France. 231 pp.

Boutrais, J., 1987. Mbozo-Wazan: Peul et montagnards au nord du Cameroun. Atlas des structures agraires au sud du Sahara No 22. ORSTOM, Paris, France. 154 pp.

Boyce, P., 1995. Culcasia seretii. Curtis's Botanical Magazine 12(3): 138–140.

Boynard, C.A. & D'Almeida, J.R.M., 1999. Water absorption by sponge gourd (Luffa cylindrica) polyester composite materials. Journal of Materials Science Letters 18: 1789–1791.

Bredenkamp, G.J., Brown, L.R. & Pfab, M.F., 2006. Conservation value of the Egoli Granite Grassland, an endemic grassland in Gauteng, South Africa. Koedoe 49(2): 59–66.

Breman, H. & de Ridder, N., 1991. Manuel sur les pâturages des pays sahéliens. ACCT, Paris, France, CTA, Wageningen, Netherlands & Karthala, Paris, France. 485 pp.

Breman, H., Cissé, A.M., Djiteye, M.A. & Elberse, W.T., 1979. Pasture dynamics and forage availability in the Sahel. Israel Journal of Botany 28(3–4): 227–251.

Brenan, J.P.M., 1953. Soyauxia, a second genus of Medusandraceae. Kew Bulletin 8: 507–511.

Brenan, J.P.M., 1959. Leguminosae subfamily Mimosoideae. In: Hubbard, C.E. & Milne-Redhead, E. (Editors). Flora of Tropical East Africa. Crown Agents for Oversea Governments and Administrations, London, United Kingdom. 173 pp.

Brenan, J.P.M., 1967a. Leguminosae, subfamily Caesalpinioideae. In: Milne-Redhead, E. & Polhill, R.M. (Editors). Flora of Tropical East Africa. Crown Agents for Oversea Governments and Administrations, London, United Kingdom. 230 pp.

Brenan, J.P.M., 1967b. The genus Entada, its subdivision and a key to the African species; notes on Mimosoïdeae 11. Kew Bulletin 20(3): 361–378.

Brenan, J.P.M., 1970. Leguminosae (Mimosoideae). In: Brenan, J.P.M. (Editor). Flora Zambesiaca. Volume 3, part 1. Crown Agents for Oversea Governments and Administrations, London, United Kingdom. 153 pp.

Brenan, J.P.M., 1979. The genus Cola - its taxonomic-economic relationships. In: Kunkel, G. (Editor). Taxonomic aspects of African economic botany. Proceedings of the 9th plenary meeting of AETFAT. Las Palmas, Gran Canaria, Spain. pp. 49–52.

Brenan, J.P.M. & Exell, A.W., 1957. Acacia pennata (L.) Willd. and its relatives in tropical Africa. Boletim da Sociedade Broteriana, Série 2, 31: 99–141.

Breteler, F.J., 1994. Novitates gabonenses (15): the genus Peddiea (Thymelaeaceae) present in Gabon. Bulletin du Jardin Botanique National de Belgique 63(3-4): 205–207.

Breteler, F.J., 2008. A synopsis of Casearia Jacq. (Samydeae – Salicaceae) in West and Central Africa with a description of a new species from Eastern Congo (Kinshasa). Kew Bulletin 63: 101–112.

Breteler, F.J., 2010. Neuropeltis (Convolvulaceae) in Upper Guinea (Africa): description of a new species with a synopsis of and a key to all African species. Systematics and Geography of Plants [in press].

Bringmann, G. & Feineis, D., 2000. Novel antiparasitic biaryl alkaloids from West African Dioncophyllaceae plants. Actualités de Chimie Thérapeutique 26: 151–171.

Bringmann, G. & Rischer, H., 2001. In vitro propagation of the alkaloid-producing rare African liana, Triphyophyllum peltatum (Dioncophyllaceae). Plant Cell Reports 20(7): 591–595.

Bringmann, G., Saeb, W., Aké Assi, L., François, G., Narayanan, A.S.S., Peters, K. & Peters, E.M., 1997. Betulinic acid. Isolation from Triphyophyllum peltatum and Ancistrocladus heyneanus, antimalarial activity, and crystal structure of the benzyl ester. Planta Medica 63(3): 255–257.

Bringmann, G., François, G., Aké Assi, L. & Schlauer, J., 1998. The alkaloids from Triphyophyllum peltatum (Dioncophyllaceae). Chimia 52: 18–28.

Bringmann, G., Messer, K., Wohlfarth, M., Kraus, J., Dumbuya, K. & Rueckert, M., 1999a. HPLC CD on-line coupling in combination with HPLC-NMR and HPLC-MS/MS for the determination of the full absolute stereostructure of new metabolites in plant extracts. Analytical Chemistry 71(14): 2678–2686.

Bringmann, G., Schlauer, J., Wolf, K., Rischer, H., Buschbom, U., Kreiner, A., Thiele, F., Duschek, M. & Aké Assi, L., 1999b. Cultivation of Triphyophyllum peltatum (Dioncophyllaceae), the part-time carnivorous plant. Carnivorous Plant Newsletter 28: 7–13.

Bringmann, G., Wenzel, M., Bringmann, H.P. & Schlauer, J., 2001. Uptake of the amino acid alanine by digestive leaves: proof of carnivory in the tropical liana Triphyophyllum peltatum (Dioncophyllaceae). Carnivorous Plants Newsletter 30: 15–21.

Bringmann, G., Messer, K., Schwöbel, B., Brun, R. & Aké Assi, L., 2003. Habropetaline A, an antimalarial naphthylisoquinoline alkaloid from Triphyophyllum peltatum. Phytochemistry 62(3): 345–349.

Bringmann, G., Ruedenauer, S., Irmer, A., Bruhn, T., Brun, R., Heimberger, T., Stuehmer, T., Bargou, R. & Chatterjee, M., 2008. Antitumoral and antileishmanial dioncoquinones and ancistroquinones from cell cultures of Triphyophyllum peltatum (Dioncophyllaceae) and Ancistrocladus abbreviatus (Ancistrocladaceae). Phytochemistry 69(13): 2501–2509.

Brink, M., 2003. Curculigo Gaertn. In: Brink, M. & Escobin, R.P. (Editors). Plant Resources of South-East Asia No 17. Fibre plants. Backhuys Publishers, Leiden, Netherlands. pp. 118–120.

Brink, M. & Jansen, P.C.M., 2003. Pandanus Parkinson. In: Brink, M. & Escobin, R.P. (Editors). Plant Resources of South-East Asia No 17. Fibre plants. Backhuys Publishers, Leiden, Netherlands. pp. 197–205.

Brink, M., Jansen, P.C.M. & Bosch, C.H., 2003. Minor fibre plants. In: Brink, M. & Escobin, R.P. (Editors). Plant Resources of South-East Asia No 17. Fibre plants. Backhuys Publishers, Leiden, Netherlands. pp. 244–300.

Brisson, R., 1988. Utilisation des plantes par les pygmées Baka: textes pour l'étude de la langue. Collège Liberman, Douala, Cameroon. 355 pp.

Brisson, J. & Chazarenc, F., 2009. Maximizing pollutant removal in constructed wetlands: Should we pay more attention to macrophyte species selection? Science of The Total Environment 407(13): 3923–3930.

Brncic, T., 2002. The ecology and patch dynamics of Megaphrynium macrostachium (Marantaceae) in southwestern Central African Republic. In: Oxford Forestry Institute. Annual report 2001. Oxford Forestry Institute, Oxford, United Kingdom.

Brochmann, C. & Rustan, Ø.H., 2002. Additions to the vascular flora of Cabo Verde 4. Garcia de Orta, Série de Botânica 16(1–2): 5–31.

Brockington, N.R., 1961. Studies of the growth of a Hyparrhenia-domnantant grassland in northern Rhodesia. II. Fertilizer responses III. The effect of fire. Grass and Forage Science 16(1): 54–64.

Brokensha, D. & Riley, B.W., 1986. Changes in the uses of plants in Mbeere, Kenya. Journal of Arid Environments 11: 75–80.

Brondani, R.P.V., Gaiotto, F.A., Missiaggia, A.A., Kirst, M., Gribel, R. & Grattapaglia, D., 2003. Microsatellite markers for Ceiba pentandra (Bombacaceae), an endangered tree species of the Amazon forest. Molecular Ecology Notes 3(2): 177–179.

Brotonegoro, S., 2003a. Furcraea foetida (L.) Haw. In: Brink, M. & Escobin, R.P. (Editors). Plant Resources of South-East Asia No 17. Fibre plants. Backhuys Publishers, Leiden, Netherlands. pp. 136–139.

Brotonegoro, S., 2003b. Lepironia articulata (Retz.) Domin. In: Brink, M. & Escobin, R.P. (Editors). Plant Resources of South-East Asia No 17. Fibre plants. Backhuys Publishers, Leiden, Netherlands. pp. 170–172.

Brown, D., 2000. Aroids: plants of the Arum family. Timber Press, Portland OR, United States. 392 pp.

Brown, N.E., 1902–1904. Asclepiadeae. In: Thiselton-Dyer, W.T. (Editor). Flora of tropical Africa. Volume 4(1). Lovell Reeve & Co, London, United Kingdom. pp. 231–503.

Brown, N.E., Hutchinson, J. & Prain, D., 1909–1913. Euphorbiaceae. In: Thiselton-Dyer, W.T. (Editor). Flora of tropical Africa. Volume 6(1). Lovell Reeve & Co., London, United Kingdom. pp. 441–1020.

Brown, K.A., Ingram, J.C., Flynn, D.F.B., Razafindrazaka, R. & Jeannoda, V., 2009. Protected area safeguard tree and shrub communities from degradation and invasion: a case study in eastern Madagascar. Environmental Management 44:136–148

Browning, J. & Gordon-Gray, K.D., 1992. Studies in Cyperaceae in southern Africa. 19. The genus Bolboschoenus. South African Journal of Botany 58(5): 380–385.

Browning, J., Gordon-Gray, K.D. & Ward, C.J., 1994. Studies in Cyperaceae in southern Africa 23: a reassessment of Schoenoplectus litoralis, Sch. subulatus and Scirpus pterolepis. South African Journal of Botany 60(3): 169–174.

Bruce, E.A., 1946. Notes on some species of the genus Cryptolepis R.Br. Kew Bulletin 1(1): 46–48.

Bruce, E.A. & Lewis, J., 1960. Loganiaceae. In: Hubbard, C.E. & Milne-Redhead, E. (Editors). Flora of Tropical East Africa. Crown Agents for Oversea Governments and Administrations, London, United Kingdom. 47 pp.

Bugés, K. & Reguero-Reza, M.T., 2007. Evaluacion preliminar de toxicidad, genotoxicidad y actividad antimicrobiana de Sida rhombifolia L. Revista Colombiana de Biotecnologia 9(1): 5–13.

Brummitt, R.K., Chikuni, A.C., Lock, J.M. & Polhill, R.M., 2007. Leguminosae, subfamily Caesalpinioideae. In: Timberlake, J.R., Pope, G.V., Polhill, R.M. & Martins, E.S. (Editors). Flora Zambesiaca. Volume 3, part 2. Royal Botanic Gardens, Kew, Richmond, United Kingdom. 218 pp.

Bruneton, J., 1995. Pharmacognosy, phytochemistry, medicinal plants. Technique & Documentation Lavoisier, Paris, France. 915 pp.

Bryan, V.S., 1955. Chromosome Studies in the Genus Sphagnum. The Bryologist 58(1): 16–39.

Bryce, J.M., 1967. The commercial timbers of Tanzania. Tanzania Forest Division, Utilisation Section, Moshi, Tanzania. 139 pp.

Bryson, C.T. & Carter, R., 2005. Weedy sedges (Cyperaceae) of the world. [Internet] Poster for Weed Science Society of America. <http://www.ars.usda.gov/ SP2UserFiles/Place/64022000/Posters/2005/ 2005_WSSA_CTB.pdf>. Accessed August 2009.

Bryson, C.T. & Carter, R., 2008. The significance of Cyperaceae as weeds. In: Naczi, F.C. & Ford, B.A. (Editors). Sedges: uses, diversity, and systematics of the Cyperaceae. Monographis in Systematic Botany from the Missouri Botanical Garden. Volume 108. pp. 15–101.

Bullock, A.A., 1953. Notes on African Asclepiadaceae 3. Kew Bulletin 8: 329–362.

Bullock, A.A., 1955. Notes on African Asclepiadaceae 6. Kew Bulletin 1955: 265–292.

Bullock, A.A., 1963. Periplocaceae. In: Hepper, F.N. (Editor). Flora of West Tropical Africa. Volume 2. 2nd Edition. Crown Agents for Oversea Governments and Administrations, London, United Kingdom. pp. 80–85.

Bullock, S.H., 1980. Demography of an undergrowth palm in littoral Cameroon. Biotropica 12(4): 247–255.

Bunda College of Agriculture, 1998. A comparison of the browsing and grazing behaviour of goats and sheep and the composition of natural pasture. [Internet] In: Improved integration of small ruminants with a view to economical and ecologically sustainable production in smallholder crop-livestock systems in southern Africa. Bunda College of Agriculture, Lilongwe, Malawi & Humboldt University of Berlin, Centre for International Agricultural Development & Institute of Animal sciences, Berlin Germany. <http://www.ilri.org/ InfoServ/Webpub/fulldocs/AnGenResCD/docs/eurep-98/ chapter5.htm>. Accessed April 2011.

Burgess, N.D. & Clarke, G.P., 2000. Coastal forests of Eastern Africa. IUCN, Gland, Swizerland. 443 pp.

Burgoon, P.S., Reddy, K.R. & DeBusk, T.A., 1989. Domestic wastewater treatment using emergent plants cultured in gravel and plastic substrate. In: Hammer, D.A. (Editor). Constructed wetlands for wastewater treatment. Lewis Publishers, Chelsea, Michigan, United States. pp. 536–541.

Burgoyne, P.M., Bredenkamp, G.J. & van Rooyen, N., 2000. Wetland vegetation in the North Eastern Sandy Highveld, Mpumalanga, South Africa. Bothalia 30(2): 187–200.

Burkill, H.M., 1985. The useful plants of West Tropical Africa. 2nd Edition. Volume 1, Families A–D. Royal Botanic Gardens, Kew, Richmond, United Kingdom. 960 pp.

Burkill, H.M., 1994. The useful plants of West Tropical Africa. 2nd Edition. Volume 2, Families E–I. Royal Botanic Gardens, Kew, Richmond, United Kingdom. 636 pp.

Burkill, H.M., 1995. The useful plants of West Tropical Africa. 2nd Edition. Volume 3, Families J–L. Royal Botanic Gardens, Kew, Richmond, United Kingdom. 857 pp.

Burkill, H.M., 1997. The useful plants of West Tropical Africa. 2nd Edition. Volume 4, Families M–R. Royal Botanic Gardens, Kew, Richmond, United Kingdom. 969 pp.

Burkill, H.M., 2000. The useful plants of West Tropical Africa. 2nd Edition. Volume 5, Families S–Z, Addenda. Royal Botanic Gardens, Kew, Richmond, United Kingdom. 686 pp.

Burrows, J.E. & Burrows, S.M., 2003. Figs of southern and South-Central Africa. Umdaus Press, Pretoria, South Africa. 379 pp.

Burrows, J.E. & Willis, C.K. (Editors), 2005. Plants of the Nyika Plateau. An account of the vegetation of the Nyika National Parks of Malawi and Zambia. [Internet] <http://www.sabonet.org.za/downloads/31_nyika/list/b_nyikalist_p49–77.pdf>. Accessed September 2009.

Busi, R., Vidotto, F., Fischer, A.J., Osuna, M.D., de Prado, R. & Ferrero, A., 2006. Patterns of resistance to ALS herbicides in smallflower umbrella sedge (Cyperus difformis) and ricefield bulrush (Schoenoplectus mucronatus). Weed Technology 20: 1004–1014.

Bussmann, R.W., 2006. Ethnobotany of the Samburu of Mt. Nyiru, South Turkana, Kenya. Journal of Ethnobiology & Ethnomedicine 2: 35.

Busson, F., 1965. Plantes alimentaires de l'ouest Africain: étude botanique, biologique et chimique. Leconte, Marseille, France. 568 pp.

Butare, I. (Editor), 2003. Pratiques culturelles, la sauvegarde et la conservation de la biodiversité en Afrique de l'ouest et du centre: actes du Séminaire-atelier de Ouagadougou, du 18 au 21 juin 2001. Ottawa, IDRC/Zoom Editions, Ottawa, Canada. 281 pp.

Byg, A. & Balslev, H., 2001a. Diversity and use of palms in Zahamena, eastern Madagascar. Biodiversity and Conservation 10(6): 951–970.

Byg, A. & Balslev, H., 2001b. Traditional knowledge of Dypsis fibrosa (Arecaceae) in eastern Madagascar. Economic Botany 55(2): 263–275.

Byg, A. & Balslev, H., 2003. Palm heart extraction in Zahamena, eastern Madagascar. Palms 47(1): 37–44.

Bystriakova, N., Kapos, V. & Lysenko, I., 2004. Bamboo biodiversity, Africa, Madagascar and the Americas. UNEP-WCMC/INBAR. UNEP-WCMC Biodiversity Series 19. Cambridge, United Kingdom. 88 pp.

CAB International, 2007. Crop Protection Compendium. Phragmites karka. [Internet] <http://www.cabicompendium.org/cpc/datasheet.asp?CCODE=PHR_KA&COUNTRY=0>. Accessed January 2010.

CAB International, 2010a. Crop Protection Compendium. Crotalaria juncea. [Internet] <http://www.cabi.org/cpc/?compid=1&dsid=17189&loadmodule=datasheet&page=868&site=161>. Accessed January 2010.

CAB International, 2010b. Forestry Compendium. Broussonetia papyrifera. [Internet] <http://www.cabi.org/fc/?compid=2&dsid=10017&loadmodule=datasheet&page=2147&site=163>. Accessed April 2011.

CAB International, 2010c. Forestry Compendium. Eucalyptus alba. [Internet] <http://www.cabi.org/fc/?compid=2&dsid=22557&loadmodule=datasheet&page=2147&site=163>. Accessed April 2011.

CAB International, 2010d. Forestry Compendium. Eucalyptus deglupta. [Internet] <http://www.cabi.org/fc/?compid=2&dsid=22622&loadmodule=datasheet&page=2147&site=163>. Accessed April 2011.

CAB International, 2010e. Forestry Compendium. Eucalyptus regnans. [Internet] <http://www.cabi.org/fc/?compid=2&dsid=22833&loadmodule=datasheet&page=2147&site=163>. Accessed April 2011.

Caballé, G., 1998. Le port autoportant des lianes tropicales : une synthèse des stratégies de croissance. Canadian Journal of Botany 76(10): 1703–1716.

Cabezas, F.J., de la Estrella, M., Aedo, C. & Velayos, M., 2005. Marantaceae of Equatorial Guinea. Annales Botanici Fennici 42(3): 173–184.

Cai, L., Wei, G.X., Van der Bijl, P. & Wu, C.D., 2000. Namibian chewing stick, Diospyros lycioides, contains antibacterial compounds against oral pathogens. Journal of Agricultural and Food Chemistry 48(3): 909–914.

Cailliez, F. & Guéneau, P., 1972. Analyse en composantes principales des propriétés technologiques des bois Malgaches. Annales des Sciences Forestières 30: 215–266.

Calabrò, S., d'Urso, S., Banoin, M., Piccolo, V. & Infascelli, A., 2007. Nutritional characteristics of forages from Niger. Italian Journal of Animal Science 6, Suppl. 1: 272–274.

Campbell, B., 1996. The miombo in transition: woodlands and welfare in Africa. Centre for International Forestry Research (CIFOR), Bogor, Indonesia. 266 pp.

Campbell, B.T., Saha, S., Percy, R., Frelichowski, J., Jenkins, J.N., Park, W., Mayee, C.D., Gotmare, V., Dessauw, D., Giband, M., Du, X., Jia, Y., Constable, G., Dillon, S., Abdurakhmonov, I.Y., Abdukarimov, A., Rizaeva, S.M., Abdullaev, A., Barroso, P.A.V., Pádua, J.G., Hoffmann, L.V. & Podolnaya, L., 2010. Status of the global cotton germplasm resources. Crop Science 50: 1161–1179.

Camus, A., 1924. Hickelia et Pseudocoix, genres nouveaux de Bambusées malgaches. Bulletin de la Société Botanique de France 71: 899–906.

Capot, J., de Meulemeester, D., Brynaert, J. & Raes, G., 1953. Recherches sur une plante à fibres: l'Abroma augusta L.f. Publications de l'Institut National pour l'Étude Agronomique du Congo Belge (INEAC). Série technique No 42. 113 pp.

Capuron, R., 1963. Révision des Tiliacées de Madagascar et des Comores (première partie). Adansonia, séries 2, 3: 91–127.

Capuron, R. & Mabberley, D.J., 1999. Révision des Malvaceae-Grewioideae ('Tiliacées', p.p.) de Madagascar et des Comores. 3. Les Grewia du sous-genre Vincentia (Benth.) Capuron. Adansonia, séries 3, 21(1): 7–23.

Carberry, P.S. & Abrecht, D.G., 1990. Germination and elongation of the hypocotyls and radicle of kenaf (Hibiscus cannabinus) in response to temperature. Field Crops Research 24(3–4): 227–240.

Carino, D.A. & Daehler, C.C., 1999. Genetic variation in an apomictic grass, Heteropogon contortus, in the Hawaiian Islands. Molecular Ecology 8: 2127–2132.

Carrière, S.M., Andrianotahiananahary, H., Ranaivoarivelo, N. & Randriamalala, J., 2005. Savoirs et usages des recrus post-agricoles du pays Betsileo: valorisation d'une biodiversité oubliée à Madagascar. VertigO 6(1) : 1–15.

Carter Ingram, J., Whittaker, R.J. & Dawson, T.P., 2005. Tree structure and diversity in human impacted littoral forests, Madagascar. Environmental Management 35(6): 779–798.

Catarino, L., 2002. Typhaceae. In: Martins, E.S., Diniz, M.A., Paiva, J., Gomes, I. & Gomes, S. (Editors). Flora de Cabo Verde: Plantas vasculares. No 101. Instituto de Investigação Científica Tropical, Lisbon, Portugal & Instituto Nacional de Investigação e Desenvolvimento Agrário, Praia, Cape Verde. 7 pp.

Catarino, L., Duarte, M.C. & Diniz, M.A., 2001. Aquatic and wetland plants in Guinea-Bissau: an overview. Systematics and Geography of Plants 71(2): 197–208.

Catarino, L., Martins, E.S. & Moreira, I., 2001. Influence of environmental features in the phytogeographic framework of Guinea-Bissau. Systematics and Geography of Plants 71(2): 1079–1086.

Catling, D.M. & Grayson, J.E., 1982. Identification of vegetable fibres. Chapman and Hall, London, United Kingdom. 89 pp.

Cavendish, W., 1999. The complexity of the commons: environmental resource demands in rural Zimbabwe. The Centre for the Study of African Economies Working Paper Series. Working Paper 92. 52 pp.

Cawe, S.G., 1999. Spatial and temporal utilisation patterns of Flagellaria guineensis Schumach. in demarcated forests of the Lusikisiki district of Transkei, South Africa. South African Journal of Botany 65(1): 69–74.

Cech, P.G., Edwards, P.J. & Olde Venterink, H., 2010. Why is abundance of herbaceous legumes low in African savanna? A test with two model species. Biotropica 42(5): 580–589.

Central Statistical Authority, 2001–2003. Estimates of area, production and yield of temporary crops for private peasants holdings for main seasons, 2001–2003. CSA, Addis Ababa, Ethiopia.

César, J., 1975. Evolutionary trends of some vegetational formations under the influence of grazing in the Guinean Savannah of the Ivory Coast. [Internet] In: Evaluation and mapping of tropical African rangelands. Proceedings of a seminar held in Bamako, Mali on 3–8 March 1975. International Livestock Centre for Africa, Addis Abeba, Ethiopia. <http://www.fao.org/ wairdocs/ ilri/x5543b/x5543b00.htm#Contents>. Accessed May 2011.

Chagnon, M., 1984. Inventaire pharmacologique général des plantes médicinales Rwandaises. Journal of Ethnopharmacology 12: 239–251.

Chan Ng Yok, H., 2009. La flore réunionaise. [Internet] <http://www.liledelareunion.com/Fr/Flore/index.htm>. Accessed October 2009.

Chang, J.-M., Huang, K.-L., Yuan, T.T.-T., Lai, Y.K. & Hung, L.M., 2010. The anti-hepatitis B virus activity of Boehmeria nivea extract in HBV-viremia SCID mice. eCAM 7(2): 189–195.

Chase, M.W., Zmarzty, S., Lledo, M.D., Wurdack, K.J., Swensen, S.M. & Fay, M.F., 2002. When in doubt, put it in Flacourtiaceae: a molecular phylogenetic analysis based on plastid rbcL DNA sequences. Kew Bulletin 57: 141–181.

Chaudhuri, S.D. & Jabbar Mia, A., 1962. Species crosses in the genus Corchorus (jute plants). Euphytica 11(1): 61–64.

Chawan, D.D. & Sen, D.N., 1973. Diversity in germination behaviour and chemical scarification for hard seed coat dormancy in Corchorus aestuans Linn. Brotéria, Série de Ciências Naturais 42 (1–2): 19–24.

CHCD, 1996. Dictionary of natural products on CD-ROM, release 4.2. Chapman & Hall, London, United Kingdom.

Cheah, C.H. & Stone, B.C., 1973. Chromosome studies of the genus Pandanus (Pandanaceae). Botanische Jahrbücher für Systematik, Pflanzengeschichte und Pflanzengeographie 93(4): 498–529.

Chee, Y.K. & Chen, C.P., 1992. Crotalaria juncea L. In: 't Mannetje, L. & Jones, R.M. (Editors). Plant Resources of South-East Asia No 4. Forages. Pudoc Scientific Publishers, Wageningen, Netherlands. pp. 98–100.

Cheek, M. & Dorr, L., 2007. Sterculiaceae. In: Beentje, H.J. & Ghazanfar, S.A. (Editors). Flora of Tropical East Africa. Royal Botanic Gardens, Kew, Richmond, United Kingdom. 134 pp.

Chejara, V.K., Kristiansen, P., Whalley, R.D.B., Sindel, B.M. & Nadolny, C., 2008. Factors affecting germination of Coolatai grass (Hyparrhenia hirta). Weed Science 56 (4): 543–548.

Chejara, V.K., Kriticos, D.J., Kristiansen, P., Sindel, B.M., Whalley, R.D.B. & Nadolny, C., 2010. The current and future potential geographical distribution of Hyparrhenia hirta. Weed Research 50: 174–184.

Chen, J. & Craven, L.A., 2007. Myrtaceae. [Internet] Flora of China 13: 321–359. <http://www.efloras.org/ florataxon.aspx?flora_id=2&taxon_id=10599>. Accessed May 2011.

Chen, J.-M. & Thompson, L.U., 2003. Lignans and tamoxifen, alone or in combination, reduce human breast cancer cell adhesion, invasion and migration in vitro. Breast Cancer Research and Treatment 80: 163–170.

Chen, J., Lin, Q., Friis, I., Wilmot-Dear, C.M. & Monro, A.K., 2003. Urticaceae. [Internet] Flora of China 5: 76–189. <http://www.efloras.org/ florataxon.aspx?flora_id=2&taxon_id=10931>. Accessed September 2011.

Chen, J.-R., Zhang X.-W., Guo Q.-Q., Tang, X.-S. & Yang, Y.-C., 2005. Construction of CCoAOMT antisense expression vector and transformation of ramie. Journal of Natural Science of Hunan Normal University 28(1): 75–78.

Chen, P.-Y, Chen, C.-H., Kuo, C.-C., Lee, T.-H., Kuo, Y.-H. & Lee, C.-K., 2011. Cytotoxic steroidal saponins from Agave sisalana. Planta Medica 77: 929–933.

Cheng, Z.-J., Lin, C.-N., Hwang, T.-L. & Teng, C.-M., 2001. Broussochalcone A, a potent antioxidant and effective suppressor of inducible nitric oxide synthase in lipopolysaccharide-activated macrophages. Biochemical Pharmacology 61(8): 939–946.

Cheng, H.S., Yusoff, M.K., Shutes, B., Ho, S.N. & Mansor, M., 2008. Nutrient removal in a pilot and full scale constructed wetland, Putrajaya city, Malaysia. Journal of Environmental Management 88: 307–317.

Chevalier, A., 1924. Une plante vivrière peu connue: le Polygala butyracea Heckel. Histoire, dispersion et affinités. Revue de Botanique Appliquée 4: 446–451.

Chevalier, A., 1937. Plantes ichthyotoxiques des colonies franfaises contenant du roténone ou presumées en contenir. Revue de Botanique Appliquée et d'Agriculture Tropicale 17: 565–585.

Chevalier, A., 1940. Une plante textile tropicale peu connue : le Cepholonema polyandrum K. Schum. et deux autres plantes à fibres. Revue Internationale de Botanique Appliquée et d'Agriculture Tropicale Coloniale 228/229: 557–564.

Chevalier, A., 1951. Plantes à fibres exploitées au Congo belge et dans le bassin du Niari (A.E.F.). Revue Internationale de Botanique Appliquée et d'Agriculture Tropicale 33(2): 441–444.

Chevalier, A. & Jacques-Félix, M.H., 1938. Polygalaceae Chev. In: Chevalier, A. (Editor). Flore vivant de l'Afrique Occidentale Française 1: 257–278.

Chew, W.L., 1967. A monograph of Laportea (Urticaceae). Gardens' Bulletin Singapore 25: 111–178.

Chhabra, S.C., Mahunnah, R.L.A. & Mshiu, E.N., 1987. Plants used in traditional medicine in eastern Tanzania. 1. Pteridophytes and Angiosperms (Acanthaceae to Canellaceae). Journal of Ethnopharmacology 21: 253–277.

Chhabra, S.C., Mahunnah, R.L.A. & Mshiu, E.N., 1990. Plants used in traditional medicine in eastern Tanzania. 3. Angiosperms (Euphorbiaceae to Menispermaceae). Journal of Ethnopharmacology 28: 255–283.

Chhabra, S.C., Uiso, F.C. & Mshiu, E.N., 1984. Phytochemical screening of Tanzanian medicinal plants. I. Journal of Ethnopharmacology 11: 157–179.

Chhetri, R.B., Kumar, N.A. & Kathirvelu, T., 2010. Evaluation of Heteropogon contortus as an alternate source for pulp & paper making. IPPTA Journal 22(2): 95–98.

Chidumayo, E.N., 1991. Seedling development of the miombo woodland tree Julbernardia globiflora. Journal of Vegetation Science 2: 21–26.

Chidumayo, E.N., 1997. Fruit production and seed predation in two miombo woodland trees in Zambia. Biotropica 29(4): 452–458.

Chifundera, K., 1987. Antivenomous plants used in the Zairean pharmacopoeia. African Study Monographs 7: 21–35.

Chifundera, K., 2001. Contribution to the inventory of medicinal plants from the Bushi area, South Kivu Province, Democratic Republic of Congo. Fitoterapia 72: 351–368.

Chikamai, B., 1997. Production, markets and quality control of gum arabic in Africa: findings and recommendations from an FAO Project. In: Conservation, management and utilization of plant gums, resins, and essential oils: Proceedings of a Regional conference for Africa held in Nairobi, Kenya October 1997. [Internet] <http://www.fao.org/ docrep/X0098e/x0098e04.htm>. Accessed January 2011.

Chikamai, B.N., Githiomi, J.K., Gachathi, F.N. & Njenga, M.G., undated. Commercial timber resources of Kenya. Kenya Forestry Research Institute (KEFRI), Nairobi, Kenya. 164 pp.

Chikoye, D., Ekeleme, F. & Gbehounou, G., 2004. Suppression of speargrass (Imperata cylindrica) in maize using sweet potato and two leguminous cover crops. Nigerian Journal of weed Sciences 17: 35–42.

Chikuni, A.C., 1994. Conservation status of mopane woodlands in Malawi: a case study of Mua Tsanya Forest Reserve. In: van der Maesen, L.J.G., van der Burgt, X.M. & van Medenbach de Rooy, J.M. (Editors). The biodiversity of African plants. Proceedings of the 14th AETFAT Congress, 22–27 August 1994, Wageningen, Netherlands. Kluwer Academic Publishers, Dordrecht, Netherlands. pp. 250–258.

Chileshe, C. & Kitalyi, A., 2002. Management of rangelands: use of natural grazing resources in Southern Province, Zambia. Technical Handbook No 28. Regional Land Management Unit (RELMA), Nairobi, Kenya. 64 pp.

Chillou, J., 1924. Note sur la culture et l'utilisation du Polygala en Guinée française. Revue de Botanique Appliquée 4: 451–454.

Chilufya, H. & Tengnäs, B., 1996. Agroforestry extension manual for northern Zambia. Regional Soil Conservation Unit, Nairobi, Kenya. 120 + 124 pp.

Chinemana, F., Drummond, R.B., Mavi, S. & de Zoysa, I., 1985. Indigenous plant remedies in Zimbabwe. Journal of Ethnopharmacology 14: 159–172.

Chippendale, G.M., 1988. Myrtaceae - Eucalyptus, Angophora. In: George, A.S. (Editor). Flora of Australia, Volume 19. Australian Government Publishing Service, Canberra, Australia. 540 pp.

Chippindall, L.K.A., 1955. A guide to the identification of grasses in South Africa. In: Meredith, D. (Editor). The grasses and pastures of South Africa. Cape Times, Cape Town, South Africa. 771 pp.

Chippindall, L.K.A. & Crook, A.O., 1976. 240 Grasses of southern Africa. 3 volumes. Collins, Salisbury, Zimbabwe.

Chira, R.M. & Kinyamario, J.I., 2009. Growth response of woody species to elephant foraging in Mwea National Reserve, Kenya. African Journal of Ecology 47(4): 598–605.

Chittenden, A.E. & Morton, D., 1955. Rushes from northern Rhodesia investigated as papermaking materials. Colonial Plant and Animal Products 5(3): 217–229.

Chittenden, A.E., Coomber, H.E. & Morton, D., 1951. Brachystegia wood from Tanganyika as a paper-making material. Colonial Plants and Animal Products (Tropical Products Institute, London) 2(4): 292–296.

Chu, C.-Y. & Lee, M.-J., 2004. Effects of arbuscular mycorrhizal fungus Acaulospora scrobiculata on growth of Hibiscus tiliaceus seedlings. Airiti Library 37(1): 37–47.

Chudnoff, M., 1980. Tropical timbers of the world. USDA Forest Service, Agricultural Handbook No 607, Washington D.C., United States. 826 pp.

CIAT/FAO, 2002–. Grassland species. [Internet]. CIAT/FAO collaboration on Tropical Forages, Rome, Italy. <http://www.fao.org/ ag/AGP/AGPC/doc/gbase/data/ pf000309.htm>. Accessed September 2009.

CIAT/FAO, undated-a. Grassland species profiles. [Internet]. CIAT/FAO collaboration on Tropical Forages, Rome, Italy. <http://www.fao.org/ ag/AGP/AGPC/doc/gbase/ Default.htm>. Accessed May 2011.

CIAT/FAO, undated-b. Hyparrhenia hirta. [Internet] In: Grassland species profiles. CIAT/FAO, Rome, Italy. <http://www.fao.org/ ag/AGP/AGPC/doc/gbase/data/ Pf000258.htm>. Accessed March 2011.

Cimanga, K., Apers, S., De Bruyne, T., Van Miert, S., Hermans, N., Totté, J., Pieters, L. & Vlietinck, A.J., 2002a. Chemical composition and antifungal activity of essential oils of some aromatic medicinal plants growing in the Democratic Republic of Congo. Journal of Essential Oil Research 14: 382–387.

Cimanga, K., Kambu, K., Tona, L., Aspers, S., De Bruyne, T., Hermans, N., Totté, J., Pieters, L. & Vlietinck, A.J., 2002b. Correlation between chemical composition and antibacterial activity of essential oils of some aromatic medicinal plants growing in the Democratic Republic of Congo. Journal of Ethnopharmacology 79: 213–220.

CIRAD Forestry Department, 2003. Fromager. [Internet] Tropix 5.0. <http://agritrop.cirad.fr>. Accessed April 2007.

CJB & SANBI, 2006. African Flowering Plants Database. [Internet] Conservatoire et Jardin botaniques de la Ville de Genève (CJB) and South African National Biodiversity Institute (SANBI), Pretoria, South Africa. <http://www.ville-ge.ch/ cjb/bd/africa/ index.php>. Accessed March 2009.

CJB & SANBI, 2009. African Flowering Plants Database. [Internet] Conservatoire et Jardin botaniques de la Ville de Genève (CJB) and South African National Biodiversity Institute (SANBI), Pretoria, South Africa. <http://www.ville-ge.ch/ musinfo/bd/cjb/africa/ recherche.php>. Accessed August 2009.

Clarke, C.B., 1901–1902. Cyperaceae. In: Thiselton-Dyer, W.T. (Editor). Flora of tropical Africa. Volume 8. Lovell Reeve & Co., London, United Kingdom. pp. 266–524.

Claβen-Bockhoff, R., 1991. Untersuchungen zur Konstruktion des Bestäubungsapparates von Thalia geniculata (Marantaceen). Botanica Acta 104: 183–193.

Clayton, W.D., 1963. Studies in the Gramineae: IV. The African species of Ctenium. Kew Bulletin 16: 471–475.

Clayton, W.D., 1966a. Studies in the Gramineae: IX. Andropogoneae. Kew Bulletin 20(2): 257–273.

Clayton, W.D., 1966b. Studies in the Gramineae: X. Andropogoneae The genus Anadelphia Hack. Kew Bulletin 20(2): 275–285.

Clayton, W.D., 1966c. Studies in the Gramineae. XI. Kew Bulletin 20(2): 287–293.

Clayton, W.D., 1966d. Studies in the Gramineae XII. Parahyparrhenia, Hyperthelia and Exotheca. Kew Bulletin 20: 433–449.

Clayton, W.D., 1969. A revision of Hyparrhenia. Kew Bulletin, Additional Series 2, H.M.S.O., London, United Kingdom. 195 pp.

Clayton, W.D., 1970a. Gramineae (part 1). In: Milne-Redhead, E. & Polhill, R.M. (Editors). Flora of Tropical East Africa. Crown Agents for Oversea Governments and Administrations, London, United Kingdom. 176 pp.

Clayton, W.D., 1970b. Studies in the Gramineae: XXI. Coelorhachis and Rhytachne: a study in numerical taxonomy. Kew Bulletin 24: 309–314.

Clayton, W.D., 1971. Studies in the Gramineae 26. Numerical taxonomy of the Arundinelleae. Kew Bulletin 26(1): 111–123.

Clayton, W.D., 1972. Gramineae. In: Hepper, F.N. (Editor). Flora of West Tropical Africa. 2nd Edition. Volume 3, part 2. pp. 277–574.

Clayton, W.D., 1973. The awnless genera of Andropogoneae. Studies in the Gramineae: XXXIII. Kew Bulletin 28(1): 49–57.

Clayton, W.D., 1975. Some discriminant functions for Hyparrhenia. Studies in the Gramineae XLI. Kew Bulletin 30(3): 511–520.

Clayton, W.D., 1978. The genus Rhytachne (Gramineae). Kew Bulletin 32(4): 767–771.

Clayton, W.D. & Renvoize, S.A., 1982. Gramineae (part 3). In: Polhill, R.M. (Editor). Flora of Tropical East Africa. A.A. Balkema, Rotterdam, Netherlands. pp. 451–898.

Clayton, W.D., Harman, K.T. & Williamson, H., 2002–. GrassBase - the online world grass flora. [Internet] Royal Botanic Gardens, Kew, United Kingdom.<http://www.kew.org/data/grasses-db/>. Accessed August 2007 - May 2011.

Clayton, W.D., Harman, K.T. & Williamson, H., 2006–. GrassBase - the online world grass flora. [Internet] Royal Botanic Gardens, Kew, United Kingdom.<http://www.kew.org/ data/grasses-db/>. Accessed January 2010.

Clayton, W.D., Phillips, S.M. & Renvoize, S.A., 1974. Gramineae (part 2). In: Polhill, R.M. (Editor). Flora of Tropical East Africa. Crown Agents for Oversea Governments and Administrations, London, United Kingdom. 273 pp.

Clayton, W.D., Vorontsova, M.S., Harman, K.T. & Williamson, H., 2002–. GrassBase - the online world grass flora. [Internet] Royal Botanic Gardens, Kew, United Kingdom.<http://www.kew.org/ data/grasses-db/>. Accessed March - May 2011.

Clevering, O.A., 1998. An investigation into the effects of nitrogen on growth and morphology of stable and die-back populations of Phragmites australis. Aquatic Botany 60(1): 11–25.

Clevering, O.A. & Lissner, J., 1999. Taxonomy, chromosome numbers, clonal diversity and population dynamics of Phragmites australis. Aquatic Botany 64: 185–208.

Coates Palgrave, K., 1983. Trees of southern Africa. 2nd Edition. Struik Publishers, Cape Town, South Africa. 959 pp.

Coates Palgrave, K., 2002. Trees of southern Africa. 3rd Edition. Struik Publishers, Cape Town, South Africa. 1212 pp.

Cocks, M.L., 2006. Wild plant resources and cultural practices in rural and urban households in South Africa: implications for bio-cultural diversity conservation. PhD thesis, Wageningen University, Netherlands. 194 pp.

Codjia, J.T.C., Assogbadjo, A.E. & Ekué, M.R.M., 2003. Diversité et valorisation au niveau local des ressources végétales forestières alimentaires du Bénin. Cahiers Agricultures 12(5): 321–331.

Cogne, A.-L., 2002. Phytochemical investigation of plants used in African traditional medicine: Dioscorea sylvatica (Dioscoreaceae), Urginea altissima (Liliaceae), Jamesbrittenia fodina and Jamesbrittenia elegantissima (Scrophulariaceae). PhD thesis, Université de Lausanne, Institut de Pharmacognosie et Phytochimie, Lausanne, Switzerland. 208 pp.

Coile, N.C. & Shilling, D.G., 1993. Cogongrass, Imperata cylindrica (L.) Beauv.: a good grass gone bad! Botany Circular 28. Florida Department of Agriculture and Consumer Services. Division of Plant Industry. Gainesville, Florida, USA. 3 pp.

Compton, S.G., Grehan, K. & van Noort, S., 2009. A fig crop pollinated by three or more species of agaonid fig wasps. African Entomology 17(2): 215–222.

Conert, H.J., 1957. Beitraege zur Monographie der Arundinelleae. Botanische Jahrbücher für Systematik, Pflanzengeschichte und Pflanzengeographie 77: 226–354.

Constantine, D., 1999–2008. The Musaceae: An annotated list of the species of Ensete, Musa and Musella. [Internet] <http://www.users.globalnet.co.uk/~drc/ musaceae.htm>. Accessed September 2010.

Conway, V.M., 1936. Studies in the autecology of Cladium mariscus R.Br. 1. Structure and development. New Phytologist 35(3): 177–204.

Conway, V.M., 1938. Studies in the autecology of Cladium mariscus R.Br. 4. Growth rates of the leaves. New Phytologist 37(3): 254–278.

Coode, M.J.E., 1982. Euphorbiacées. In: Bosser, J., Cadet, T., Guého, J. & Marais, W. (Editors). Flore des Mascareignes. Familles 153–160. The Sugar Industry Research Institute, Mauritius, l'Office de la Recherche Scientifique Outre-Mer, Paris, France & Royal Botanic Gardens, Kew, Richmond, United Kingdom. 117 pp.

Cook, C.G. & Mullin, B.A., 1994. Growth response of kenaf cultivars in root-knot nematode/soil-borne fungi infested soil. Crop Science 34(6): 1455–1457.

Cook, C.G. & White, G.A., 1996. Crotalaria juncea: a potential multi-purpose fibre crop. In: Janick, J. (Editor), Progress in new crops. ASHS Press, Alexandria, Virginia, United States. pp. 389–394.

Cook, J.A., VanderJagt, D.J., Pastuszyn, A., Mounkaila, G., Glew, R.S., Millson, M. & Glew, R.H., 2000. Nutrient and chemical composition of 13 wild plant foods of Niger. Journal of Food Composition and Analysis 13(1): 83–92.

Cook, B., Pengelly, B., Brown, S., Donnelly, J., Eagles, D., Franco, A., Hanson, J., Mullen, B., Partridge, I., Peters, M. & Schultze-Kraft, R., 2005. Heteropogon contortus. [Internet] Factsheet in: Tropical forages: An interactive selection tool. CSIRO Sustainable Ecosystems, Department of Primary Industries & Fisheries, Queensland, Australia, Centro Internacional de Agricultura Tropical, Cali, Colombia and International Livestock Research Institute, Nairobi, Kenya. <http://www.tropicalforages.info/key/ Forages/Media/Html/ Heteropogon_contortus.htm>. Accessed March 2011.

Cooper, G.P. & Record, S.J., 1931. The evergreen forests of Liberia. School of Forestry, Yale University, Bulletin 31, New Haven, United States. 153 pp.

Cooper, H.D., Spillane, C. & Hodgkin, T., 2001. Broadening the genetic base of crop production. CABI, Wallingford, United Kingdom. 452 pp.

Cope, T.A., 1995. Poaceae (Gramineae). In: Thulin, M. (Editor). Flora of Somalia. Volume 4. Angiospermae (Hydrocharitaceae-Pandanaceae). Royal Botanic Gardens, Kew, Richmond, United Kingdom. pp. 148–270.

Cope, T.A., 1998. A synopsis of Eragrostis Wolf (Poaceae) in the Flora Zambesiaca area. Kew Bulletin 53(1): 129–164.

Cope, T., 1999. Gramineae (Arundineae, Eragrostideae, Leptureae and Cynodonteae). In: Pope, G.V. (Editor). Flora Zambesiaca. Volume 10, part 2. Royal Botanic Gardens, Kew, Richmond, United Kingdom. 261 pp.

Cope, T.A., 2002. Gramineae, tribe Andropogoneae. In: Pope, G.V. & Martins, E.S. (Editors). Flora Zambesiaca. Volume 10, part 4. Royal Botanic Gardens, Kew, Richmond, United Kingdom. 190 pp.

Coppen, J.J.W., 2002. Eucalyptus: the genus Eucalyptus. Medicinal and aromatic plants - industrial profiles, vol. 22. Taylor & Francis, London, United Kingdom. 450 pp.

Corley, M.F.V., Crundwell, A.C., Düll, R., Hill, M.O. & Smith, A.J.E., 1981. Mosses of Europe and the Azores; an annotated list of species, with synonyms from the recent literature. Journal of Bryology 11: 609–689.

Cornelius, J.A., Hammonds, T.W., Leicester, J.B., Ndabahweji, J.K., Rosie, D.A. & Shone, G.G., 1970. New tropical seed oils. 3. Component acids of leguminous and other seed oils (continued). Journal of the Science of Food and Agriculture 21(1): 49–50.

Cos, P., Hermans, N., de Bruyne, T., Apers, S., Sindambiwe, J.B., Vanden Berghe, D.A., Pieters, L. & Vlietinck, A.J., 2002. Further evaluation of Rwandan medicinal plant extracts for their antimicrobial and antiviral activities. Journal of Ethnopharmacology 79: 155–163.

Costermans, L., 1983. Native trees and shrubs of south-eastern Australia. Revised edition. New Holland Publishers, Sydney, Australia. 424 pp.

Coughenour, M.B., McNaughton, S.J. & Wallace, L.L., 1985. Responses of an African tall-grass (Hyparrhenia filipendula Stapf.) to defoliation and limitations of water and nitrogen. Oecologia 68(1): 80–86.

CPBR, 2006. EUCLID: Eucalypts of Australia. 3rd Edition. [Internet] Centre for Plant Biodiversity Research, Canberra, Australia. <http://www.anbg.gov.au/ cpbr/cd-keys/euclid3/euclidsample/html/ Eucalyptus_regnans.htm>. Accessed May 2009.

Crane, J.C., Acuna, J.B. & Alanso, R.E., 1946. Effect of plant spacing and time of planting on fiber yield of kenaf, Hibiscus cannabinus L. Journal of the American Society of Agronomy 38(1): 46–59.

Cremers, G., 1974. Architecture de quelques lianes d'Afrique tropicale. 2. Candollea 29: 57–110.

Crosby, M.R., Schultze-Motel, U. & Schultze-Motel, W., 1983. Katalog der Laubmoose von Madagaskar und den umliegenden Inseln. Willdenowia 13: 187–255.

CSIR, 1956. The wealth of India. A dictionary of Indian raw materials and industrial products. Raw materials. Volume 4: F–G. Council of Scientific and Industrial Research, New Delhi, India. 287 pp.

CSIR, 1966. The wealth of India. A dictionary of Indian raw materials & industrial products. Raw materials. Volume 7: N–Pe. Publications and Information Directorate, Council of Scientific and Industrial Research, New Delhi, India. 330 pp.

CSIR, 1969. The wealth of India. A dictionary of Indian raw materials & industrial products. Raw materials. Volume 8: Ph–Re. Publications and Information Directorate, Council of Scientific and Industrial Research, New Delhi, India. 394 pp.

CSIR, 1976. The wealth of India. A dictionary of Indian raw materials & industrial products. Raw materials. Volume 10: Sp–W. Publications and Information Directorate, Council of Scientific and Industrial Research, New Delhi, India. 591 pp.

CSIR, 1985. The wealth of India. A dictionary of Indian raw materials and industrial products. Raw materials. Revised Edition. Volume 1. Publications and Information Directorate, New Delhi, India. 513 pp.

CTFT (Centre Technique Forestier Tropical), 1975. Fromager. Bois et Forêts des Tropiques 163: 37–51.

Cuccuini, P., 1993. Thymelaeaceae. In: Thulin, M. (Editor). Flora of Somalia. Volume 1. Pteridophyta; Gymnospermae; Angiospermae (Annonaceae-Fabaceae). Royal Botanic Gardens, Kew, Richmond, United Kingdom. pp. 200–202.

Cuenoud, P., Savolainen, V., Chatrou, L.W., Powell, M., Grayer, R.J. & Chase, M.W., 2002. Molecular phylogenetics of Caryophyllales based on nuclear 18S rDNA and plastid rbcL, atpB, and matK DNA sequences. American Journal of Botany 89(1): 132–144.

Cui, S.W., 2001. Polysaccharide gums from agricultural products: Processing, structures & functionality. Technomic Publishing, Lancaster, United States. 269 pp.

Cuidet, Y., Rivière, J.M., Picot, F. & Boullet, V., 2006. Index de la flore vasculaire de la Réunion. Liste des espèces menacées sur le territoire de la Réunion 6. [Internet] <http://flore.cbnm.org/ index.php?fold=menace&page=menace_6&extand=true>. Accessed Februari 2010.

Cullis, C.A., 2005. Mechanisms and control of rapid genomic changes in flax. Annals of Botany 95: 201–206.

Cunningham, A.B., 1990. Income, sap yield and effects of sap tapping on palms in south-eastern Africa. South African Journal of Botany 56(2): 137–144.

Cunningham, A.B., 1996. People, park and plant use: recommendations for multiple-use zones and development alternatives around Bwindi Impenetrable National Park, Uganda. UNESCO People and Plants Working Paper 4, Paris, France. 58 pp.

Cunningham, A.B. & Wehmeyer, A.S., 1988. Nutritional value of palm wine from Hyphaene coricaceae and Phoenix reclinata (Arecaceae). Economic Botany 42(3): 301–306.

Cunningham, R.L., Clark, T.F. & Bagby, M.O., 1978. Crotalaria juncea; annual source of papermaking fibre. TAPPI 61(2): 37–39.

Curtis, B. & Mannheimer, C., 2005. Tree Atlas of Namibia. National Botanical Research Institute, Windhoek, Namibia. 674 pp. [Internet] <http://www.biodiversity.org.na/ treeatlas/SpPDFs/ Sp161.pdf>. Accessed March - May 2010.

d'Oliveira Feijão, R., 1960. Elucidário fitológico. Plantas vulgares de Portugal continental, insular e ultramarino. Classificão, nomes vernáculos e aplicações. Volume 1, A–H. Instituto Botânico de Lisboa, Lisbon, Portugal. 472 pp.

d'Oliveira Feijão, R., 1961. Elucidário fitológico. Plantas vulgares de Portugal continental, insular e ultramarino. Classificão, nomes vernáculos e aplicações. Volume 2, I–O. Instituto Botânico de Lisboa, Lisbon, Portugal. 462 pp.

d'Oliveira Feijão, R., 1963. Elucidário fitológico. Plantas vulgares de Portugal continental, insular e ultramarino. Classificão, nomes vernáculos e aplicações. Volume 3, P–Z. Instituto Botânico de Lisboa, Lisbon, Portugal. 394 pp.

d'Orey, J.D.S., 1981. Marantacae colhidas por John Gossweiler em Angola existentes em LISJC. Garcia de Orta, Série de Botânica 5(1): 47–57.

da Silva, B.P., Campos, P.O. & Parente, J.P., 2006. Chemical structure and biological activity of steroidal saponins from Furcraea gigantea. Chemistry of Natural Compounds 42(3): 316–321.

da Silva, M.C., Izidine, S. & Amude, A.B., 2004. A preliminary checklist of the vascular plants of Mozambique. Southern African Botanical Diversity Network Report No 30. SABONET, Pretoria, South Africa. 183 pp.

Dahal, K.R., Utomo, B.I. & Brink, M., 2003. Agave sisalana Perrine. In: Brink, M. & Escobin, R.P. (Editors). Plant Resources of South-East Asia No 17. Fibre plants. Backhuys Publishers, Leiden, Netherlands. pp. 68–75.

Dahlgren, R.M.T., Clifford, H.T. & Yeo, P.F., 1985. The families of the Monocotyledons: structure, evolution and taxonomy. Springer-Verlag, Berlin, Germany. 520 pp.

Dai, L.-K., Liang, S.-Y., Zhang, S., Tang, Y., Koyama, T., Tucker, G.C., Simpson, D.A., Noltie, H.J., Strong, M.T., Bruhl, J.J., Wilson, K.L. & Muasya, A.M. (Editors), 2010. Cyperaceae. [Internet] Flora of China, Science Press, Beijing, China and Missouri Botanical Garden Press, St. Louis MO, United States. 23: 164–461. <http://www.efloras.org/ florataxon.aspx?flora_id=2&taxon_id=10246>. Accessed June 2011.

Dairo, F.A.S., Aye, P.A. & Oluwasola, T.A., 2007. Some functional properties of loofah gourd (Luffa cylindrica L., M.J.Roem) seed. Journal of Food, Agriculture & Environment 5(1): 97–101.

Dale, I.R., 1953. A descriptive list of the introduced trees of the Uganda protectorate. The Government Printer, Entebbe, Uganda. 76 pp.

Dalibard, C., 1999. Overall view on the tradition of tapping palm trees and prospects for animal production. [Internet] Livestock Research for Rural Development 11(1). <http://www.lrrd.org/ lrrd11/1/ dali111.htm>. Accessed February 2011.

Dalziel, J.M., 1937. The useful plants of West Tropical Africa. Crown Agents for Overseas Governments and Administrations, London, United Kingdom. 612 pp.

Daniel, M., 2006. Medicinal plants: chemistry and properties. Science Publishers, Enfield, New Hampshire, United States. 250 pp.

Daniels, R.E., 1991. Variation in performance of Phragmites australis in experimental culture. Aquatic Botany 42: 41–48.

Darbyshire, I., 2004. Raphia regalis. In: IUCN. 2010 Red list of threatened species. Version 2010.4. [Internet] <http://www.iucnredlist.org>. Accessed January 2011.

Darko, S.N., 2009. Antihypertensive action of ethanolic extract of Imperata cylindrica leaf. BSc Biochemistry degree thesis, Department of Biochemistry, Faculty of Biosciences, Kwame Nkrumah University of Science and Technology, Kumasi, Ghana. 29 pp.

Dasuki, U.A., 2003. Cyperus L. In: Brink, M. & Escobin, R.P. (Editors). Plant Resources of South East Asia No 17. Fibre plants. Backhuys Publishers, Leiden, Netherlands. pp. 121–125.

Dauget, J.M. & Menaut, J.C., 1995. Eléments sur la dynamique de population de cinq espèces ligneuses dominantes dans la savane de Lamto (Côte d'Ivoire) à partir de mesures de croissance individuelle à long terme. Candollea 50 (2): 255–265.

David, O.M. & Falegan, C.R., 2007. Effect of fermentation on physicochemical and antibacterial activity of cottonseed oil. Journal of Pure and Applied Microbiology 1(2): 181–184.

Davidse, G., 1984. A new species of Rhytachne (Poaceae: Andropogoneae) from northern south America. Brittonia 36(4): 402–405.

Davidson, R.L., 1962. The influence of edaphic factors on the species composition of early stages of the subsere [secondary succession]. Journal of Ecology 50(2): 401–410.

Davis, M.A., 1987. The role of flower visitors in the explosive pollination of Thalia geniculata (Marantaceae), a Costa Rican marsh plant. Bulletin of the Torrey Botanical Club 114(2): 134–138.

Dawkins, H.C., 1956. Rapid detection of aberrant girth increment of rain-forest trees. Empire Forestry Review 35: 449–454.

DCD, undated. Gossypium herbaceum cotton in India. [Internet] Directorate of Cotton Development, Ministry of Agriculture and Cooperation, Mumbai, India. <http://dcd.dacnet.nic.in/ herbaceum.htm>. Accessed October 2011.

de Boer, H.J., Kool, A., Broberg, A., Mziray, W.R., Hedberg, I. & Levensfors, J.L., 2005. Anti-fungal and anti-bacterial activity of some herbal remedies from Tanzania. Journal of Ethnopharmacology 96: 461–469.

de Cordemoy, E.J., 1895. Flore de l'île de la Réunion (Phanérogames, Cryptogames vasculaires, Muscinées), avec l'indication des propriétés économiques et industrielles des plantes. Paul Klincksieck, Paris, France. 574 pp.

de Kerchove de Denterghem, O., 1878. Les palmiers, histoire iconographique. J. Rothschild, Paris, France. 348 pp.

de Koning, J., 1983. La forêt de Banco. Part 2: La Flore. Mededelingen Landbouwhogeschool Wageningen 83–1. Wageningen, Netherlands. 921 pp.

de la Estrella, M., Cabezas, F.J., Aedo, C. & Velayos, M., 2010. The Papilionoideae (Leguminosae) of Equatorial Guinea (Annobón, Bioko and Río Muni). Folia Geobotanica 45(1): 1–57.

de la Mensbruge, G., 1966. La germination et les plantules des essences arborées de la forêt dense humide de la Côte d'Ivoire. Centre Technique Forestier Tropical, Nogent-sur-Marne, France. 389 pp.

de Rouw, A., 1993. Regeneration by sprouting in slash and burn rice cultivation, Taï rain forest, Côte d'Ivoire. Journal of Tropical Ecology 9: 387–408.

de Souza, S., 1982. Remarques anatomiques sur trois espèces de Raphia du Bénin: Raphia hookeri Mann & Wendl., R. vinifera P. Beauv. et R. sudanica A. Chev. Bulletin de l'Institut Français d'Afrique Noire, Série A 44(3–4): 280–294.

de Souza, S., 1987. Catalogue des plantes du Bénin. Flore du Bénin. Volume 1. Université Nationale du Bénin, Cotonou, Benin. 81 pp.

de Wet, H., Fouche, G. & van Heerden, F.R., 2009. In vitro cytotoxicity of crude alkaloidal extracts of South African Menispermaceae against three cancer cell lines. African Journal of Biotechnology 8(14): 3332–3335.

de Wilde, W.J.J.O., 1970. A survey of the species of the genus Adenia (Passifloraceae) in Madagascar, with some new combinations, the description of some new taxa, and a key to the species. Adansonia, n.s. 10(1): 111–126.

de Wilde, W.J.J.O., 1971. A monograph of the genus Adenia Forsk. (Passifloraceae). Mededelingen Landbouwhogeschool Wageningen 71–18. Wageningen, Netherlands. 281 pp.

de Wilde, W.J.J.O., 1974. Account on Efulensia (Passifloraceae). Blumea 22: 31–35.

de Wilde, W.J.J.O., 1975. Passifloraceae. In: Polhill, R.M. (Editor). Flora of Tropical East Africa. Crown Agents for Oversea Governments and Administrations, London, United Kingdom. 71 pp.

De Wildeman, E., 1903–1905. Notices sur des plantes utiles ou interessantes de la flore du Congo. Volume 1. Imprimerie Veuve Monnom, Brussels, Belgium. 662 pp.

De Wildeman, E., 1919. Additions à la Flore du Congo II. Bulletin du Jardin botanique de l'État a Bruxelles 5(3): 269–364.

de Winter, B., 1963. Ebenaceae. In: Dyer, R.A. & Codd, L.E. (Editors). Flora of southern Africa. Volume 26. Botanical Research Institute, Department of Agricultural Technical Services, Pretoria, South Africa. pp. 54–99.

de Winter, B., 1969. A new species of Eragrostis from South West Africa. Bothalia 10(1): 72.

Debray, M., Jacquemin, H. & Razafindrambao, R., 1971. Contribution à l'inventaire des plantes médicinales de Madagascar. Travaux et Documents No 8. ORSTOM, Paris, France. 150 pp.

Decary, R., 1946. Plantes et animaux utiles de Madagascar. Annales du Musée Colonial de Marseille, 54e année, 6e série, 4e volume, 1er et dernier fascicule. 234 pp.

Deckers, J., Ngatunga, E.L. & Msafiri, H.E., 2001. Sisal. In: Raemaekers, R.H. (Editor). Crop production in tropical Africa. DGIC (Directorate General for International Coöperation), Ministry of Foreign Affairs, External Trade and International Coöperation, Brussels, Belgium. pp. 1076–1082.

Defo, L., 1997. La filière des produits forestiers non-ligneux: l'example du rotin au Sud Cameroun. Department of Geography, University of Yaounde, Cameroon.

Defo, L., 1999. Rattan or porcupine? Benefits and limitations of a high-value NWFP for conservation in the Yaounde region of Cameroon. In: Sunderland, T.C.H., Clark, L.E. & Vantomme, P. (Editors). Non-wood forest products of Central Africa: current research issues and prospects for conservation and development. Food and Agriculture Organisation, Rome, Italy. pp. 237–244.

Defo, L., 2004. Rattan exploitation in the Yaounde region of Cameroon. In: Sunderland, T. & Ndoye, O. (Editors). Forest Products, livelihoods and conservation. Case studies of non-timber forest product systems. Volume 2, Africa. CIFOR, Bogor, Indonesia. pp. 291–316.

Dehmlow, E.V., van Ree, T., Jakupovic, J., Take, E. & Künsting Jr, H., 1998. Notes on activity tests and constituents of two supposed medicinal plants from South Africa, Englerophytum magalismontanum and Diospyros lycioides Desf. subsp. sericea. Journal of Chemical Research, Part S 1998(5): 252–253.

Deka, D.K., Lahon, L.C., Saikia, J. & Mukit, A., 1994. Effect of Cissus quadrangularis in accelerating healing process of experimentally fracture radius ulna of dog: A preliminary study. Indian Journal of Pharmacology 26(1): 44–45.

Delwaulle, J.-C., 1979. Plantations forestières en Afrique tropicale sèche. Techniques et espèces à utiliser. Bois et Forêts des Tropiques 187: 3–30.

Demaret, F., 1954. Additions à la flore bryologique du Congo Belge. Bulletin du Jardin botanique de l'État à Bruxelles 24(1): 51–55.

Demissew Sebsebe, 2001. A synopsis of the genus Merremia (Convolvulaceae) in the Flora of Ethiopia and Eritrea. Kew Bulletin 56(4): 931–943.

Dempsey, J.M., 1975. Fiber crops. University Presses of Florida, Gainesville, Florida, United States. 457 pp.

Denton, L., 1997. A review of Corchorus olitorius L. in Nigeria. In: Schippers, R.R. & Budd, L. (Editors). Proceedings of a workshop on African indigenous vegetables, Limbe, Cameroon, 13–18 January 1997. Natural Resources Institute/IPGRI, Chatham, United Kingdom. pp. 25–30.

Deokota, R. & Chhetri, R.B., 2009. Traditional knowledge on wild fiber processing of allo in Bhedetar of Sunsari District, Nepal. Kathmandu University Journal of Science, Engineering and Technology 5(1): 136–142.

Descoings, B., 1967. Vitacées (Vitaceae). Flore de Madagascar et des Comores (plantes vasculaires), familles 124–124 bis. Muséum National d'Histoire Naturelle, Paris, France. 156 pp.

Descoings, B., 1997. Vitacées. In: Bosser, J., Cadet, T., Guého, J. & Marais, W. (Editors). Flore des Mascareignes. Familles 69–79. The Sugar Industry Research Institute, Mauritius, l'Institut Français de Recherche Scientifique pour le Développement en Coopération (ORSTOM), Paris, France & Royal Botanic Gardens, Kew, Richmond, United Kingdom. 10 pp.

Desouter, S., 1991. Pharmacopée humaine et vétérinaire du Rwanda. Annales Sciences Economiques 22. Institut National de Recherche Scientifique, Butare, Rwanda. Musée Royal de l'Afrique Centrale, Tervuren, Belgium. 252 pp.

Devmurari, V.P., Ghodasara, T.J. & Jivani, N.P., 2010. Antibacterial activity and phytochemical study of ethanolic extract of Triumfetta rhomboidea Jacq. International Journal of PharmTech Research 2(2): 1182–1186.

Dhankhar, B.S. & Mishra, J.P., 2004. Objectives of okra breeding. In: Singh, P.S., Dasgupta, S.K. & Tripathi, S.K. (Editors). Hybrid vegetable development. Food Products Press, New York, USA. pp. 195–209.

Dharani, N., 2002. Field guide to common trees and shrubs of East Africa. Struik Publishers, Cape Town, South Africa. 320 pp.

Dhetchuvi, M.M., 1993. Biologie et usage de quelques espèces de Marantaceae au Zaïre. Belgian Journal of Botany 126(2): 209–216.

Dhetchuvi, M.M., 1996a. Taxonomie et phytogéographie des Marantaceae et Zingiberaceae de l'Afrique Centrale (Gabon, Congo, Zaïre, Rwanda et Burundi). PhD thesis, Université Libre de Bruxelles, Brussels, Belgium. 438 pp.

Dhetchuvi, M.M., 1996b. The genus Marantochloa (Marantaceae) in Africa. Bulletin du Jardin Botanique National de Belgique 65(3–4): 369–398.

Diack, M., Sene, M., Badiane, A.N., Diatta, M. & Dick, R.P., 2000. Decomposition of a native shrub, Piliostigma reticulatum, litter in soils of semiarid Senegal. Arid Land Research and Management 14(3): 205–218.

Diafouka, A. & Lejoly, J., 1996. Plantes hypotensives utilisées en médecine traditionnelle à Brazzaville (Congo). In: Schröder, E., Balansard, G., Cabalion, P., Fleurentin, J. & Mazars, G. (Editors). Médicaments et aliments: approche ethnopharmacologique. Actes du 2e Colloque Européen d'Ethnopharmacologie et de la 1le Conférence Internationale d'Ethnomédecine. Heidelberg (Allemagne), 24–27 mars 1993. ORSTOM Editions, Paris, France. pp. 275–276.

Diallo, N., 1994. L'arbre et la haie dans les systèmes agraires de la préfecture de Faranah. Flamboyant 31: 24–29.

Diallo, A., de Wispelaere, G., Lebrun, J.-P. & Riviere, R., 1968. Paturages naturels du 'Ferlo-Sud' (République du Senegal). Institut d'Elevage et de Médecine Vétérinaire des Pays Tropicaux, Maisons-Alfort, France. Etudes Agrostologiques No. 23. 173 pp.

Dick, M.A., Dobbie, K., Cooke, D.E.L. & Brasier, C.M., 2006. Phytophthora captiosa sp. nov. and P. fallax sp. nov. causing crown dieback of Eucalyptus in New Zealand. Mycological Research 110(4): 393–404.

Dignan, P., King, M., Saveneh, A. & Walters, M., 1998. The regeneration of Eucalyptus regnans F. Muell. under retained overwood: seedling growth and density. Forest Ecology and Management 102(1): 1–7.

Diogo, R.V.C., Buerkert, A. & Schlecht, E., 2010. Resource use efficiency in urban and peri-urban sheep, goat and cattle enterprises. Animal 4(10): 1725–1738.

Diouf, M., Diop, M., Lo, C., Drame, K.A., Sène, E., Ba, C.O., Guèye, M. & Faye, B., 1999. Sénégal. In: Chweya, J.A. & Eyzaguirre, P.B. (Editors). The biodiversity of traditional leafy vegetables. IPGRI, Rome, Italy. pp. 111–154.

Dixit, B.S., Srivastava, S.N. & Sharma, V.N., 1974. Chemical examination of the seeds of Corchorus aestuans Linn. Indian Journal of Chemistry 12(7): 780.

Dixon, A.B., 2001. Indigenous knowledge: its significance for wetland management in Illubabor Zone. In: Dixon, A.B., Afework Hailu & Wood, A.P. (Editors). Proceedings of the Wetland Awareness Creation and Activity Identification Workshop in Amhara National Regional State, January 23rd 2001, Bahar Dar, Ethiopia. pp. 53–60.

Doat, J. & Valette, J.C., 1980. L'inflammabilité de quelques bois tropicaux. Bois et Forêts des Tropiques 194: 43–55.

Dongmo, A.B., Nguelefack, T. & Lacaille-Dubois, M.A., 2005. Antinociceptive and anti-inflammatory activities of Acacia pennata wild (Mimosaceae). Journal of Ethnopharmacology 98(1-2): 201–206.

Dongmo, A.B., Miyamoto, T., Yoshikawa, K., Arihara, S. & Lacaille-Dubois, M.A., 2007. Flavonoids from Acacia pennata and their cyclooxygenase (COX-1 and COX-2) inhibitory activities. Planta Medica 73(11):1202–1207.

Dörgeloh, W.G., 1999. Chemical quality of the burnt and non-burnt grass layer in the Nylsvlei Nature Reserve, South Africa. African Journal of Ecology 37(2): 168–179.

Dossa, E.L., Khouma, M., Diedhiou, I., Sene, M., Kizito, F., Badiane, A.N., Samba, S.A.N. & Dick, R.P., 2009. Carbon, nitrogen and phosphorus mineralization potential of semiarid Sahelian soils amended with native shrub residues. Geoderma 148(3–4): 251–260.

Dosumu, O.O., Nwosu, F.O. & Nwogu, C.D., 2006. Antimicrobial studies and phytochemical screening of extracts of Hyphaene thebaica (L.) Mart. fruits. International Journal of Tropical Medicine 1(4): 186–189.

Dougall, H.W. & Bogdan, A.V., 1958. The chemical composition of grasses of Kenya. East African Agricultural and Forestry Journal 24(1): 17–23 (Part 1), 25(4): 241–244 (Part 2).

Dowd, M.K., 2011. Cottonseed oil. In: Gunstone, F.D. (Editor). Vegetable oils in food technology: composition, properties and uses. 2nd Edition. Blackwell Publishing, Oxford, United Kingdom. pp. 199–224.

Dowe, J.L., 2009. A taxonomic account of Livistona R.Br. (Arecaceae). Gardens' Bulletin Singapore 60(2): 185–344.

Dowsett-Lemaire, F., 1996. Composition et évolution de la végétation forestière au Parc National d'Odzala, Congo. Bulletin du Jardin Botanique National de Belgique 65: 253–292.

Dransfield, J., 1986. Palmae. In: Polhill, R.M. (Editor). Flora of Tropical East Africa. A.A. Balkema, Rotterdam, Netherlands. 55 pp.

Dransfield, S., 1994. The genus Hickelia (Gramineae: Bambusoideae). Kew Bulletin 49(3): 429–443.

Dransfield, J., 1999. Madagascar as a source of new palm introductions. Acta Horticulturae 486: 21–32.

Dransfield, J. & Beentje, H.J., 1995. The palms of Madagascar. Royal Botanic Gardens, Kew and The International Palm Society, United Kingdom. 475 pp.

Dransfield, J. & Beentje, H.J., 1998a. Dypsis utilis. In: IUCN 2010. IUCN Red List of Threatened Species. Version 2010.3. [Internet] <http://www.iucnredlist.org>. Accessed September 2010.

Dransfield, J. & Beentje, H.J., 1998b. Ravenea lakatra. In: IUCN. 2010 Red list of threatened species. Version 2010.3. [Internet] <http://www.iucnredlist.org>. Accessed October 2010.

Dransfield, J. & Beentje, H.J., 1998c. Ravenea xerophila. In: IUCN. 2010 Red list of threatened species. Version 2010.3. [Internet] <http://www.iucnredlist.org>. Accessed October 2010.

Dransfield, J. & Uhl, N.W., 1983. Wissmannia (Palmae) reduced to Livistona. Kew Bulletin 38(2): 199–200.

Drew, A. & Reilly, C., 1972. Observations on copper tolerance in the vegetation of a Zambian copper clearing. Journal of Ecology 60(2): 439–444.

Dreyer, J. & Edom, G., 2005. Nettle. In: Franck, R.R. (Editor). Bast and other plant fibres. Woodhead Publishing, Cambridge, United Kingdom & CRC Press, Boca Raton, Florida, United States. pp. 331–343.

Drummond, R.B., 1981. Common trees of the central watershed woodlands of Zimbabwe. Department of Natural Resources, Causeway, Zimbabwe. 256 pp.

Du, Q., Xu, Y., Li, L., Zhao, Y., Jerz, G. & Winterhalter, P., 2006. Antioxidant constituents in the fruits of Luffa cylindrica (L.) Roem. Journal of Agricultural and Food Chemistry 54(12): 4186–4190.

du Puy, D.J., Labat, J.N., Rabevohitra, R., Villiers, J.-F., Bosser, J. & Moat, J., 2002. The Leguminosae of Madagascar. Royal Botanic Gardens, Kew, Richmond, United Kingdom. 750 pp.

du Toit, J.C.O., 2010. Species/defoliation/drought interactions on tuft survival and tiller and phytomass production in four sourveld grass species in KwaZulu-Natal, South Africa. African Journal of Range & Forage Science 27(1): 57–60.

Duangjai, S., Samuel, R., Munzinger, J., Forest, F., Wallnoefer, B., Barfuss, M.H.J., Fischer, G. & Chase, M.W., 2009. A multi-locus plastid phylogenetic analysis of the pantropical genus Diospyros (Ebenaceae), with an emphasis on the radiation and biogeographic origins of the New Caledonian endemic species. Molecular Phylogenetics and Evolution 52(3): 602–620.

Duarte, M.C., Gomes, I. & Moreira, I., 2002. Ilha de Santiago (Cabo Verde): notas florísticas e fitogeográficas (2). Garcia de Orta, Série de Botânica 15(1): 55–58.

Dubois, L., 1951. Note sur les principales plantes à fibres indigènes utilisées au Congo belge et au Ruanda-Urundi. Bulletin Agricole du Congo Belge 42: 870–890.

Dujardin, M., 1978. Chromosome numbers of some tropical African grasses from western Zaire. Canadian Journal of Botany 56(17): 2138–2152.

Dujardin, M., 1979. Additional chromosome numbers and meiotic behaviour in tropical African grasses from western Zaire. Canadian Journal of Botany 57: 864–876.

Duke, J.A., 1983a. Crotalaria juncea L. In: Duke, J.A. (Editor). Handbook of Energy Crops. [Internet] <http://www.hort.purdue.edu/ newcrop/duke_energy/ Crotalaria_juncea.html>. Accessed January 2010.

Duke, J.A., 1983b. Cyperus papyrus L. In: Duke, J.A. (Editor). Handbook of energy crops. [Internet] <http://www.hort.purdue.edu/ newcrop/duke_energy/ Cyperus_papyrus.html>. Accessed May 2009.

Duke, J.A., 1998. Phragmites australis (Cav.) Trin. ex Steud. In: Duke, J.A. (Editor). Handbook of energy crops. [Internet] <http://www.hort.purdue.edu/ newcrop/duke_energy/ Phragmites_australis.html>. Accessed October 2009.

Dumetz, N., 1999. High plant diversity of lowland rainforest vestiges in eastern Madagascar. Biodiversity and Conservation 8(2): 273–315.

Dunsmore, J.R., 1998. Crafts, cash and conservation in highland Nepal. Community Development Journal 33(1): 49–56.

Dupriez, H. & De Leener, P., 1987. Jardins et vergers d'Afrique. Terres et Vie, Nivelles, Belgium. 354 pp.

Dutt, D. & Tyagi, C.H., 2011. Comparison of various eucalyptus species for their morphological, chemical, pulp and paper making characteristics. Indian Journal of Chemical Technology 18: 145–151.

Dweck, A.C., undated. A review of the paper mulberry (Broussonetia papyrifera) (L.) Hert. ex Vent. [Internet] <http://www.dweckdata.com/Published_papers/Broussonetia_papyrifer.pdf>. Accessed March 2011.

Dwuma Badu, D., Okarter, T.U., Tackie, A.N., Lopez, J.A., Slatkin, D.J., Knapp, J.E. & Schiff, P.L. jr, 1977. Constituents of West African medicinal plants 19: funiferine N-oxide, a new alkaloid from Tiliacora funifera (Menispermaceae). Journal of Pharmaceutical Science 66(9): 1242–1244.

Dwuma Badu, D., Withers, S.F., Ampofo, S.A., El Azizi, M.M., Reighard, J.B., Knapp, J.E., Slatkin, D.J. & Schiff, P.L. jr., 1978. Constituents of West African medicinal plants. 23. The position of the phenolic function in dinklacorine and funiferine – confirmation of structures. Lloydia 41: 658.

Eastern Arc Mountains & Coastal Forests CEPF Plant Assessment Project Participants, 2006. Bulbostylis hispidula. In: IUCN. 2010 IUCN Red list of threatened species. Version 2010.4. [Internet] <http://www.iucnredlist.org>. Accessed May 2011.

Eastern Arc Mountains & Coastal Forests CEPF Plant Assessment Project Participants, 2008. Pandanus rabaiensis. In: IUCN. 2010 IUCN Red list of threatened species. Version 2010.4. [Internet] <http://www.iucnredlist.org>. Accessed March 2011.

Ebanyenle, E. & Oteng-Amoako, A.A., 2003. Anatomy and identification of five indigenous rattan species of Ghana. Ghana Journal of Forestry 11(2): 77–90.

Ebanyenle, E. & Oteng-Amoako, A.A., 2005. Variation in some anatomical and physical properties of stems of five rattan palm species of Ghana. Journal of Bamboo and Rattan 4(2): 125–142.

ECOCROP, 2007a. Gossypium arboreum. [Internet]. FAO, Rome, Italy. <http://ecocrop.fao.org/ecocrop/srv/en/ dataSheet?id=6492>. Accessed September 2011.

ECOCROP, 2007b. Gossypium barbadense. [Internet]. FAO, Rome, Italy. <http://ecocrop.fao.org/ecocrop/srv/en/ dataSheet?id=1158>. Accessed September 2011.

ECOCROP, 2007c. Gossypium herbaceum. [Internet]. FAO, Rome, Italy. <ecocrop.fao.org/ecocrop/srv/en/dataSheet?id=6493>. Accessed September 2011.

ECOCROP, 2007d. Gossypium hirsutum. [Internet]. FAO, Rome, Italy. <ecocrop.fao.org/ecocrop/srv/en/dataSheet?id=1160>. Accessed September 2011.

ECOCROP, 2007e. Trachypogon spicatus. [Internet]. FAO, Rome, Italy. <http://ecocrop.fao.org/ecocrop/srv/en/ cropView?id=148306>. Accessed June 2011.

Eddy, A., 1985. A revision of African Sphagnales. Bulletin of the British Museum (Natural History). Botany 12: 77–162.

Edem, D.O., Eka, O.U. & Ifon, E.T., 1984. Chemical evaluation of the nutritive value of the Raffia palm fruit (Raphia hookeri). Food Chemistry 15(1): 9–17.

Edmonds, J.M., 1990. Herbarium survey of African Corchorus L. species. Systematic and Ecogeographic Studies on Crop Genepools 4. IBPGR/IJO, Rome, Italy. 284 pp.

Edmonds, J.M., 1991. The distribution of Hibiscus L. section Furcaria in tropical East Africa. Systematic and Ecogeographic studies on crop genepools 6. IBPGR, Rome, Italy. 60 pp.

Edwards, S., 1997. Flagellariaceae. In: Edwards, S., Mesfin Tadesse, Demissew Sebsebe & Hedberg, I. (Editors). Flora of Ethiopia and Eritrea. Volume 6. Hydrocharitaceae to Arecaceae. The National Herbarium, Addis Ababa University, Addis Ababa, Ethiopia and Department of Systematic Botany, Uppsala University, Uppsala, Sweden. p. 512.

Edwards, S. & Egziabher, T.B.G., 1997. Arecaceae (Palmae). In: Edwards, S., Mesfin Tadesse, Demissew Sebsebe & Hedberg, I. (Editors). Flora of Ethiopia and Eritrea. Volume 6. Hydrocharitaceae to Arecaceae. The National Herbarium, Addis Ababa University, Addis Ababa, Ethiopia and Department of Systematic Botany, Uppsala University, Uppsala, Sweden. pp. 513–526.

Edwards, P., Kollmann, J. & Fleischmann, K., 2002. Life history evolution in Lodoicea maldivica (Arecaceae). Nordic Journal of Botany 22(2): 227–237.

Eggeling, W.J. & Dale, I.R., 1951. The indigenous trees of the Uganda Protectorate. Government Printer, Entebbe, Uganda. 491 pp.

Eicher, C.K., Maredia, K. & Sithole-Niang, I., 2006. Crop biotechnology and the African farmer. Food Policy 31: 504–527.

Ekstam, B. & Forseby, A., 1999. Germination response of Phragmites australis and Typha latifolia to diurnal fluctuations in temperature. Seed Science Research 9(2): 157–163.

Ekundayo, E.O & Ezeogu, L.I., 2006. Evaluation of antimicrobial activities of extracts of five plants used in traditional medicine in Nigeria. International Journal of Tropical Medicine 1(2): 93–96.

El Tahir, I.M., 1991. Okra genetic resources in Sudan. Report of an international workshop on okra genetic resources held at the National Bureau for Plant Genetic Resources, New Delhi, India, 8–12 October 1990. International Crop Network Series No 5. IBPGR, Rome, Italy. pp. 34–35.

El-Adawy, T.A. & Khalil, A.H., 1994. Characteristics of roselle seeds as a new source of protein and lipid. Journal of Agriculture & Food Chemistry 42: 1986–1900.

Eldahshan, O.A., Ayoub, N.A., Singab, A.B. & Al-Azizi, M.M., 2008. Potential superoxide anion radical scavenging activity of doum palm (Hyphaene thebaica) leaves extracts. Records of Natural Products 2(3): 83–93.

Eldin, N.S. & Amin, E.M., 1981. Review of research on the pests of kenaf and their control in the Sudan. Beiträge zur tropischen Landwirtschaft und Veterinarmedizin 19(4): 433–437.

Eldridge, K., Davidson, J., Harwood, C. & van Wijk, G., 1993. Eucalypt domestication and breeding. Clarendon Press, Oxford, United Kingdom. xix + 288 pp.

Elevitch, C.R. & Thomson, L.A.J., 2006. Hibiscus tiliaceus (beach hibiscus). [Internet] In: Elevitch, C.R. (Editor). Species profiles for Pacific Island agroforestry. Permanent Agriculture Resources, Holualoa, HI, United States. <http://agroforestry.net/ tti/H.tiliaceus-beach-hibiscus.pdf>. Accessed August 2011.

El-Fiky, F.K., Abou-Karam, M.A. & Afify, E.A., 1996. Effect of Luffa aegyptiaca (seeds) and Carissa edulis (leaves) extracts on blood glucose level of normal and streptozotocin diabetic rats. Journal of Ethnopharmacology 50: 43–47.

El-Gamal, S.A., Omar, F.A. & Mahmoud, M.M., 1997. Effect of nitrogen fertilization on the growth and yield of Hibiscus sabdariffa L. Acta Horticulturae 144: 135–144.

El-Gendy, A.A., El-Mileegy, A., Ghyaty, E., Malek, H. & El-Hamid Mousa, A., 2009. The beneficial dietary hypotensive and hypolipidaemic effects of Hyphaene thebaica (doum). [Internet] The Internet Journal of Alternative Medicine 7(1). <http://www.ispub.com /journal/the_internet_journal_of_alternative_medicine/volume_7_number_1_22/article/ the_beneficial_dietary_hypotensive_and_hypolipidaemic_effects_of_hyphaene_thebaica_doum.html>. Accessed February 2011.

Ellery, K., Ellery, W.N. & Verhagen, B.Th., 1992. The distribution of C3 and C4 plants in a successional sequence in the Okavango Delta. South African Journal of Botany 58(5): 400–402.

Ellery, W.N., McCarthy, T.S. & Smith, N.D., 2003. Vegetation, hydrology, and sedimentation patterns on the major distributary system of the Okavango Fan, Botswana. Wetlands 23(2): 357–375.

Ellison, D. & Ellison, A., 2001. Cultivated palms of the world. University of New South Wales Press, Sydney, Australia. 257 pp.

El-Sayed, M.M., Abdel-Hameed, E.S., El-Nahas, H.A. & El-Wakil, E.A, 2006. Isolation and identification of some steroidal glycosides of Furcraea selloa. Pharmazie 61(5): 478–482.

Elujoba, A.A., Odeleye, O.M. & Ogunyemi, C.M., 2005. Traditional medicine development for medical and dental health care delivery system in Africa. African Journal of Complementary and Alternative Medicines 2(1): 46–61.

English, R.G., 1998. The regulation of axillary bud development in the rhizomes of cogongrass (Imperata cylindrica (L.) Beauv.). Ph.D. dissertation, University of Florida, Gainesville, Florida, USA. 123 pp.

Engloner, A.I., 2009. Structure, growth dynamics and biomass of reed (Phragmites australis) - a review. Flora 204: 331–346.

Eniola-Tijani, H. & Fawusi, M.O.A., 1991. Influence of extracts from fresh samples of five tropical weeds on seed germination and early seedling development of selected crop species. Ife Journal of Agriculture 13(1–2): 38–48.

Enobakhare, D.A., 1994. Occurrence and distribution of Cerataphis palmae (Ghesquierei) (Homoptera: Pemphigidae) on Raphia palms in southern Nigeria. Insect Science and its Application 15(1): 101–104.

Eromosele, I.C., Eromosele, C.O. & Funmilayo, D.O., 2008. Grafting of acrylonitrile onto allylated caesarweed fibers by potassium permanganate - N, N'-dimethylacetamide redox pair. Journal of Applied Polymer Science 110(5): 2671–2675.

Escobin, R.P., 2003. Boehmeria nivea (L.) Gaudich. In: Brink, M. & Escobin, R.P. (Editors). Plant Resources of South-East Asia No 17. Fibre plants. Backhuys Publishers, Leiden, Netherlands. pp. 86–91.

Escobin, R.P. & Widodo, S.H., 2003. Urena lobata L. In: Brink, M. & Escobin, R.P. (Editors). Plant Resources of South-East Asia No 17. Fibre plants. Backhuys Publishers, Leiden, Netherlands. pp. 106–114.

Esquinas-Alcazar, J.T. & Gulick, P.J., 1983. Genetic resources of Cucurbitaceae. IBPGR, Rome, Italy. 101 pp.

Evans, L.T., 1975. Photoperiodism and photosynthetic pathways. Canadian Journal of Botany 53: 590–591.

Everson, C.S. & Tainton, N.M., 1984. The effect of thirty years of burning on the Highland Sourveld of Natal. Journal of the Grassland Society of Southern Africa 1(3): 15–20.

Evrard, C. & Bamps, P., 1959. Révision du genre Haumania J. Léonard (Marantaceae) au Congo Belge. Bulletin du Jardin botanique de l'État a Bruxelles 29(4): 367–375.

Ewango, C.E.N., 2010. The liana assemblage of a Congolian rainforest: diversity, structure and dynamics. PhD Thesis, Wageningen University, Wageningen, the Netherlands. 161 pp.

Exell, A.W., 1960. Polygalaceae. In: Exell, A.W. & Wild, H. (Editors). Flora Zambesiaca. Volume 1, part 1. Crown Agents for Oversea Governments and Administrations, London, United Kingdom. pp. 303–336.

Exell, A.W. & Meeuse, A.D.J., 1961. Malvaceae. In: Exell, A.W. & Wild, H. (Editors). Flora Zambesiaca. Volume 1, part 2. Crown Agents for Oversea Governments and Administrations, London, United Kingdom. pp. 420–511.

Exell, A.W. & Roessler, H., 1969. Malvaceae. Prodromus einer Flora von Südwestafrika. No 82. J. Cramer, Germany. 32 pp.

Eyog Matig, O., Ndoye, O., Kengue, J. & Awono, A. (Editors), 2006. Les fruitiers forestiers comestibles du Cameroun. IPGRI Regional Office for West and Central Africa, Cotonou, Benin. 204 pp.

Fafioye, O.O., Adebisi, A.A. & Fagade, S.O, 2004. Toxicity of Parkia biglobosa and Raphia vinifera extracts on Clarias gariepinus juveniles. African Journal of Biotechnology 3(11): 627–630.

Faihun, F.C., 2001. Utilisation des fibres végétales dans la confection des tuiles: étude comparative des caractéristiques physico-mécaniques des tuiles en Fibromortier et Vibromortier. Thèse pour l'obtention du diplôme d'ingénieur agronome, Faculté des Sciences Agronomiques, Université d'Abomey Calavi, Cotonou, Bénin. 63 pp.

Fairhead, J. & Leach, M., 1996. Misreading the African landscape: society and ecology in a forest–savanna mosaic. African Studies Series No 90. Cambridge University Press, Cambridge, United Kingdom. 354 pp.

Falconer, J., 1994. Non-timber forest products in southern Ghana: main report. Natural Resources Institute, Chatham Maritime, United Kingdom. 244 pp.

Fall, S.T., 1991. Digestibilité in vitro et dégradabilité in situ dans le rumen de ligneux fourragers disponibles sur pâturages naturels au Sénégal. Premiers résultats. Revue d'Elevage et de Médecine Vétérinaire des Pays Tropicaux 44(3): 345–354.

Fanshawe, D.B., 1972. The biology of the reed - Phragmites mauritianus Kunth. Kirkia 8(2): 147–150.

FAO, 1958. Principal pests and diseases of eucalypts outside Australia. Unasylva 12(2): 77–79.

FAO, 1974. Tree planting practices in African savannas. FAO Forestry Development Paper No 19. FAO, Rome, Italy. 185 pp.

FAO, 1988. Traditional food plants: a resource book for promoting the exploitation and consumption of food plants in arid, semi-arid and sub-humid lands of Eastern Africa. FAO food and nutrition paper 42. FAO, Rome, Italy. 593 pp.

FAO, 2004. Sisal production and marketing in China: retrospect and prospect. [Internet] In: Consultation on natural fibres, Rome, 12–14 December 2000. ESC-Fibres Consultation No 5. FAO, Rome, Italy. <http://www.fao.org/ es/esc/common/ecg/350/en/ esc_5e.pdf>. Accessed September 2011.

FAO, 2007. Jute, kenaf, sisal, abaca, coir, and allied fibers—Statistics 2006. [Internet] <ftp://ftp.fao.org/ docrep/fao/meeting/009/ j9330m.pdf>. Accessed September 2010.

FAO, 2009. Abaca. International Year of Natural Fibers. [Internet] <http://www.naturalfibres2009.org/ en/fibres/ abaca.html>. Accessed September 2010.

FAO, 2010. FAOSTAT. [Internet] <http://faostat.fao.org/ site/291/ default.aspx>. Accessed September 2010.

FAO, 2011. FAOSTAT. [Internet] <http://faostat.fao.org/ site/291/ default.aspx>. Accessed September - October 2011.

FAO-AGSI, 1999. Post-Harvest Compendium. [Internet]. FAO, Rome, Italy. <http://www.fao.org/inpho/compend/text/ch28/ch28.htm>. Accessed June 2004.

Faparusi, S.I., 1981. Sugars identified in Raphia palm wine. Food Chemistry 7(2): 81–86.

Farooqi, J.A., 1986. Cyclopropenoid fatty acids in Abutilon ramosum seed oil. Fette, Seifen, Anstrichmittel 88(3): 94–95.

Farron, C., 1968. Contribution à la taxonomie des Ouratéeae (Ochnaceae). Candollea 23: 177 228.

Faurix, E., Rakotomalala, L., Delcroix, F., Nerine, E., Randriamidina, P. & Telolahy, A., 1989. L'espace économique et les activités productives dans les villages Sakalava de Maharivo. In: AOMBE 2 : Elevage et société. Ministère de la Recherche Scientifique et Technologique pour le Développement de la République Malagasy & ORSTOM, Antananarivo, Madagascar. pp. 93–135.

Fawole, O.A., Ndhlala, A.R., Amoo, S.O., Finnie, J.F. & van Staden, J., 2009. Anti-inflammatory and phytochemical properties of twelve medicinal plants used for treating gastro-intestinal ailments in South Africa. Journal of Ethnopharmacology 123(2): 237–243.

Fedeniuk, R.W. & Biliaderis, C.B., 1994. Composition and physicochemical properties of linseed (Linum usitatissimum L.) mucilage. Journal of Agricultural and Food Chemistry 42: 240–247.

Fedorov, A.A., 1974. Chromosome numbers of flowering plants. Reprint. Otto Koeltz Science Publishers, Koenigstein, Germany. 926 pp.

Fér, T. & Hroudová, Z., 2009. Genetic diversity and dispersal of Phragmites in a small river system. Aquatic Botany 90(2): 165–171.

Fernandez de la Pradilla, C., 1978. Plantes médicinales vendues sur les marchés de Ouagadougou. Rapport, deuxième édition. Petit Séminaire de Pabre, Ouagadougou, Burkina Faso. 46 pp.

Ferreira, M.A., Alves, A.C. & Figueira de Sousa, A., 1972. Naphthoquinones of Diospyros heterotricha. Garcia de Orta, Serie de Farmacognosia 1(1): 29–31.

Ferreira, M.A., Cruz Costa, M.A. & Alves, A.C., 1972. Identification of methylnaphthazarin in Diospyros species. Phytochemistry 11(7): 2352–2353.

Feuell, A.J. & Jarman, C.G., 1951. Pavonia urens fibre from Uganda. Colonial Plant and Animal Products 2: 306–309.

Feuillet, C. & MacDougal, J.M., 2007. Passifloraceae. In: Kubitzki, K. (Editor). The families and genera of vascular plants. Volume 9. Flowering plants - eudicots. Springer-Verlag, Berlin, Germany. pp. 270–281.

Fischer, A.J., Strong G.L., Shackel, K. & Mutters, R.G., 2010. Temporary drought can selectively suppress Schoenoplectus mucronatus in rice. Aquatic Botany 92(4): 257–264.

Fisseha Mesfin, 2007. An ethnobotanical study of medicinal plants in Wonago Woreda, SNNPR, Ethiopia. MSc thesis, Addis Ababa University, Addis Ababa, Ethiopia. 74 pp.

Fisseha Mesfin, Sebsebe Demissew & Tilahun Teklehaymanot, 2009. An ethnobotanical study of medicinal plants in Wonago Woreda, SNNPR, Ethiopia. Journal of Ethnobiology and Ethnomedicine 5: 28.

Fleischmann, K., Edwards, P.J., Ramseier, D. & Kollmann, J., 2005. Stand structure, species diversity and regeneration of an endemic palm forest on the Seychelles. African Journal of Ecology 43(4): 291–301.

Fletcher, R.J., 2004. Pseudocereals, overview. In: Wrigley, C., Corke, H. & Walker., C. (Editors). Encyclopedia of grain science. pp. 488–493.

Fleuret, A., 1980. Nonfood uses of plants in Usambara. Economic Botany 34(4): 320–333.

Focho, D.A., Ndam, W.T. & Fonge, B.A., 2009. Medicinal plants of Aguambu - Bamumbu in the Lebialem highlands, southwest province of Cameroon. African Journal of Pharmacy and Pharmacology 3(1): 1–13.

Ford, H. & Bealey, C., 2004. Status of the Bankouale palm, Livistona carinensis, in Djibouti. Palms 48(2): 94–101.

Ford, H., Conochie, G., Trathan, P. & Gillet, H., 2008. The decline of the Bankouale palm in Djibouti: el Nino and changes in architectural fashion. Palms 52(2): 89–95.

FOREAIM, 2008. Bridging restoration and multi-functionality in degraded forest landscape of Eastern Africa and Indian Ocean Islands. Scientific Report, CIRAD, Montpellier, France. 113 pp.

Forest Products Commission, 2008. Timber Advisory Note No 11: Mountain Ash – Eucalyptus regnans. [Internet] Department of Conservation and Land Management, Como, Australia. <http://www.agric.wa.gov.au/ PC_92542.html?s=929287663>. Accessed May 2009.

Fortin, Y. & Poliquin, J., 1976. Natural durability and preservation of one hundred tropical African woods. International Development Research Centre, Ottawa, Canada. 131 pp.

Fortin, D., Lô, M. & Maynart, G., 1990. Plantes médicinales du Sahel. ENDA, Dakar, Senegal & CECI, Montréal, Canada. 280 pp.

Foti, S., Garnaccia, P. & Patane, C., 1998. Production of kenaf (Hibiscus cannabinus L.) seed in Sicily. Agricoltura Ricerca 20(178): 69–78.

Fougère-Danezan, M., Herendeen, S., Maumont, S. & Bruneau, A., 2010. Morphological evolution in the variable resin-producing Detarieae (Fabaceae): do morphological characters retain a phylogenetic signal? Annals of Botany 105(2): 311–325.

Fouilloy, R. & Hallé, N., 1973. Sapindacées. Flore du Cameroun. Volume 16. Muséum National d'Histoire Naturelle, Paris, France. 202 pp.

Fowler, D.G., 2006. Traditional fever remedies: a list of Zambian plants. [Internet] <http://www.giftsofhealth.org/ ritam/news/ Traditional_Fever_remedie1.pdf>. Accessed May 2011.

Fowler, D.G., 2007. Zambian plants: their vernacular names and uses. Kew Publishing, Kew, Richmond, United Kingdom. 298 pp.

Francis, J.K. (Editor), 2004. Wildland shrubs of the United States and its territories: thamnic descriptions: volume 1. General Technical Report IITF-GTR-26. United States Department of Agriculture, Forest Service, International Institute of Tropical Forestry, San Juan, United States & U. S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fort Collins, United States. 830 pp.

Franck, R.R. (Editor), 2005. Bast and other plant fibres. Woodhead Publishing, Cambridge, United Kingdom & CRC Press, Boca Raton, Florida, United States. 397 pp.

François, G., Timperman, G., Haller, R.D., Bar, S., Isahakia, M.A., Robertson, S.A., Zhao, C., De Souza, N.J., Aké Assi, L., Holenz, J. & Bringmann, G., 1997. Growth inhibition of asexual erythrocytic forms of Plasmodium falciparum and P. berghei in vitro by naphthylisoquinoline alkaloid-containing extracts of Ancistrocladus and Triphyophyllum species. International Journal of Pharmacognosy 35(1): 55–59.

Fraser, L.F., Carty, S.M. & Steer, D., 2004. A test of four plant species to reduce total nitrogen and total phosphorus from soil leachate in subsurface wetland microcosms. Bioresource Technology 94: 185–192.

Freedman, R., 1998. Famine foods. Sterculiaceae. [Internet] Purdue University, West Lafayette, Indiana, United States. <http://www.hort.purdue.edu/ newcrop/faminefoods/ff_families/ STERCULIACEAE.html>. Accessed September 2009.

Freiburghaus, F., Ogwal, E.N., Nkunya, M.H.H., Kaminsky, R. & Brun, R., 1996. In vitro antitrypanosomal activity of African plants used in traditional medicine in Uganda to treat sleeping sickness. Tropical Medecine and International Health 1(6): 765–771.

Friedmann, F., 1987. Sterculiacées. In: Bosser, J., Cadet, T., Guého, J. & Marais, W. (Editors). Flore des Mascareignes. Familles 51–62. The Sugar Industry Research Institute, Mauritius, l'Office de la Recherche Scientifique Outre-Mer, Paris, France & Royal Botanic Gardens, Kew, Richmond, United Kingdom. 50 pp.

Friedmann, F., 1994. Flore des Seychelles: Dicotylédones. Editions de l'ORSTOM, Paris, France. 663 pp.

Friis, I., 1981. A synopsis of Girardinia (Urticaceae). Kew Bulletin 36(1): 143–157.

Friis, I., 1983. A synopsis of Obetia (Urticaceae). Kew Bulletin 38(2): 221–228.

Friis, I., 1986. The genus Urera (Urticaceae) in eastern tropical Africa. Nordic Journal of Botany 5: 547–553.

Friis, I., 1989a. Moraceae. In: Hedberg, I. & Edwards, S. (Editors). Flora of Ethiopia. Volume 3. Pittosporaceae to Araliaceae. The National Herbarium, Addis Ababa University, Addis Ababa, Ethiopia and Department of Systematic Botany, Uppsala University, Uppsala, Sweden. pp. 271–301.

Friis, I., 1989b. Urticaceae. In: Hedberg, I. & Edwards, S. (Editors). Flora of Ethiopia. Volume 3. Pittosporaceae to Araliaceae. The National Herbarium, Addis Ababa University, Addis Ababa, Ethiopia and Department of Systematic Botany, Uppsala University, Uppsala, Sweden. pp. 302–325.

Friis, I., 1989c. Urticaceae. In: Polhill, R.M. (Editor). Flora of Tropical East Africa. A.A. Balkema, Rotterdam, Netherlands. 64 pp.

Friis, I., 1991. Urticaceae. In: Launert, E. & Pope, G.V. (Editors). Flora Zambesiaca. Volume 9, part 6. Flora Zambesiaca Managing Committee, London, United Kingdom. pp. 79–116.

Friis, I., 1999. Moraceae. In: Thulin, M. (Editor). Flora of Somalia. Volume 2. Angiospermae (Tiliaceae-Apiaceae). Royal Botanic Gardens, Kew, Richmond, United Kingdom. pp. 91–104.

Friis, I. & Immelman, K.L., 2001. Urticaceae. In: Germishuizen, G. (Editor). Flora of southern Africa. Volume 9. National Botanical Institute, Pretoria, South Africa. 36 pp.

Friis, I. & Vollesen, K., 1998. Flora of the Sudan-Uganda border area east of the Nile. I. Catalogue of vascular plants, 1st part. Biologiske Skrifter No 51:1. The Royal Danish Academy of Sciences and Letters, Copenhagen, Denmark. 388 pp.

Fryxell, P.A., 1978. The natural history of the cotton tribe (Malvaceae, tribe Gossypieae). Texas A & M University Press, College Station, Texas, United States. 245 pp.
Fryxell, P.A., 2010. The position of the African Wissadula rostrata in the predominantly neotropical genus Wissadula. Bonplandia 19(1): 5–10.
Fryxell, P.A. & Stelly, D.M., 1993. Documented chromosome numbers 1993: 2. Additional chromosome counts in the Malvaceae. Sida 15: 639–647.
Fugro, P.A. & Jadhav, N.V., 2003. Stem canker of okra in Konkan region of Maharashtra. Journal of Mycology and Plant Pathology 33(2): 288–289.
Gade, D.W., 1996. Deforestation and Its Effects in Highland Madagascar. Mountain Research and Development 16(2): 101–116.
Gaffney, J.F. & Shilling, D.G., 1996. The response of Imperata cylindrica to chemical control followed by revegetation with desirable species. In: Brown, H. (editor). Proceedings of the Second International Weed Control Congress. Copenhagen, Denmark, June 25–28, 1996. Department of Weed Control and Pesticide Ecology, Slagelse, Denmark. pp. 981–986.
Galeffi, C., Federici, E., Msonthi, J.D., Marini-Bettolo, G.B. & Nicoletti, M., 1990. New xanthones from Ectiadiopsis oblongifolia and Securidaca longipedunculata. Fitoterapia 61(1): 79–81.
Gambley, C.F., Thomas, J.E., Magnaye, L.V. & Herradura, L., 2004. Abacá mosaic virus: a distinct strain of sugarcane mosaic virus. Australasian Plant Pathology 33(4): 475–484.
Ganunga, R.P., Yerokun, O. & Kumwenda, J.D.T., 2005. Contribution of Tithonia diversifolia to yield and nutrient uptake of maize in Malawian small-scale agriculture. South African Journal of Plant and Soil 22(4): 240–245.
Gao Chien & Crosby, M.R. (Editors), 1999–2002. Moss flora of China - English edition. Vol. 1: Sphagnaceae – Leucobryaceae. [Internet] Science Press, Beijing, China and Missouri Botanical Garden Press, St. Louis MO, United States. <http://www.efloras.org/ flora_page.aspx?flora_id=4>. Accessed 2010.
Garcia-Mendoza, A. & Chiang, F., 2003. The confusion of Agave vivipara L. and A. angustifolia Haw., two distinct taxa. Brittonia 55(1): 82–87.
Garine, E., 2005. Evolution des ressources en matières grasses chez les Duupa (Massif de Poli, Nord-Cameroun). In: Raimond, C., Garine, E. & Langlois, O. (Editors). Ressources vivrières et choix alimentaires dans le bassin du lac Tchad. IRD Éditions, Paris, France & Prodig Éditions, Paris, France. pp. 133–151.
Gassita, J.N., Nze Ekekang, L., De Vecchy, H., Louis, A.M., Koudogbo, B. & Ekomié, R. (Editors), 1982. Les plantes médicinales du Gabon. CENAREST, IPHAMETRA, mission ethnobotanique de l'ACCT au Gabon, 10–31 juillet 1982. 26 pp.
Gaudet, J.J., 1977. Uptake, accumulation, and loss of nutrients by papyrus in tropical swamps. Ecology 58 (2): 415–422.
Gautier, D., 1995. The pole-cutting practice in the Bamileke country (western Cameroon). Agroforestry Systems 31: 21–37.
Gautier-Béguin, D., 1992. Plantes de cueillette à utilisation alimentaire en Côte d'Ivoire Centrale. Boissiera 46. 341 pp.
Gaydou, E.M. & Ramanoelina, A.R.P., 1984. Cyclopropenoic fatty acids of Malvaceae seed oils by gas-liquid chromatography. Fette, Seifen, Anstrichmittel 86(2): 82–84.
Gaydou, A.M., Bianchini, J.P., Rabarisoa, I. & Ravelojaona, G., 1980. Plantes oléagineuses endémiques de Madagascar. 1. Etude de la composition en acides gras et en stérols de quelques espèces de palmiers. Oléagineux 35(8–9): 413–415.
Gbeassor, M., Kedjagni, A.Y., Koumaglo, K., de Souza, C., Agbo, K., Aklikokou, K. & Amegbo, K.A., 1990. In vitro antimalarial activity of six medicinal plants. Phytotherapy Research 4(3): 115–117.
Geerinck, D., 1974. Notes taxonomiques sur des Orchidacées d"Afrique centrale. Bulletin de la Société Royale de Botanique de Belgique 107: 53–60.
Geerling, C., 1982. Guide de terrain des ligneux Sahéliens et Soudano-Guinéens. Mededelingen Landbouwhogeschool Wageningen 82–3. Wageningen, Netherlands. 340 pp.
Geerling, C., 1984. The Pteleopsis habeensis woodlands of Yankari Game Reserve, Nigeria. Biological Conservation 30: 359–362.
Geerling, C., 1985. The status of the woody species of the Sudan and Sahel zones of West Africa. Forest Ecology and Management 13: 247–255.

Geissler, P.W., Harris, S.A., Prince, R.J., Olsen, A., Achieng' Odhiambo, R., Oketch-Rabah, H., Madiega, P.A., Andersen, A. & Mølgaard, P., 2002. Medicinal plants used by Luo mothers and children in Bondo district, Kenya. Journal of Ethnopharmacology 83: 39–54.

Gelfand, M., Mavi, S., Drummond, R.B. & Ndemera, B., 1985. The traditional medical practitioner in Zimbabwe: his principles of practice and pharmacopoeia. Mambo Press, Gweru, Zimbabwe. 411 pp.

Gemedo-Dalle, T., Maass, B.L. & Isselstein, J., 2005. Plant biodiversity and ethnobotany of Borana pastoralists in southern Oromia, Ethiopia. Economic Botany 59(1): 43–65.

Gentry, H.S., 1982. Agaves of continental North America. The University of Arizona Press, Tucson, Arizona, United States. 670 pp.

Georgen, E. & Daehler, C.C., 2002. Factors affecting seedling recruitment in an invasive grass (Pennisetum setaceum) and a native grass (Heteropogon contortus) in the Hawaiian Islands. Plant Ecology 161: 147–156.

Gerlach, J., 2003. Pollination in the coco-de-mer, Lodoicea maldivica. Palms 47(3): 135–138.

Germain, R., 1965. Les biotopes alluvionnaires herbeux et les savanes intercalaires du Congo équatorial. Mémoires de l'Academie Royale des Sciences d'Outre-Mer, Classe des Sciences naturelles et medicales, Nouvelle Série 15(4): 1–399.

Germain, R. & Bamps, P., 1963. Sterculiaceae. In: Robyns, W., Staner, P., Demaret, F., Germain, R., Gilbert, G., Hauman, L., Homès, M., Jurion, F., Lebrun, J., Vanden Abeele, M. & Boutique, R. (Editors). Flore du Congo belge et du Ruanda-Urundi. Spermatophytes. Volume 10. Institut National pour l'Étude Agronomique du Congo belge, Brussels, Belgium. pp. 205–316.

Gessler, M.C., Nkunya, M.H.H., Mwasumbi, L.B., Heinrich, M. & Tanner, M., 1994. Screening Tanzanian medicinal plants for antimalarial activity. Acta Tropica 56: 65–77.

Getter, K.L. & Rowe, D.B., 2008. Selecting plants for extensive green roofs in the United States. Extension Bulletin E-3047. Michigan State University, East Lansing, Michigan, United States. 9 pp.

Ghebru, B. & Mehari, T. (Editors), 2007. Innovative agricultural approaches of promoting food security in Eritrea: trends, challenges and opportunities for growth. Proceedings of ta Workshop of the Association of Eritreans in Agricultural Sciences (AEAS). Geographica Bernensia, Bern, Switzerland. 169 pp.

Gibbs, P. & Semir, J., 2003. A taxonomic revision of the genus Ceiba Mill. (Bombacaceae). Anales del Jardín Botánico de Madrid 60(2): 259–300.

Gibbs Russell, G.E., Watson, L., Koekemoer, M., Smook, L., Barker, N.P., Anderson, H.M. & Dallwitz, M.J., 1990. Grasses of Southern Africa: an identification manual with keys, descriptions, distributions, classification and automated identification and information retrieval from computerized data. Memoirs of the Botanical Survey of South Africa No 58. National Botanic Gardens / Botanical Research Institute, Pretoria, South Africa. 437 pp.

Giday, M., Asfaw, Z. & Woldu, Z., 2009. Medicinal plants of the Meinit ethnic group of Ethiopia: An ethnobotanical study. Journal of Ethnopharmacology 124(3): 513–521.

Giday, M., Asfaw, Z. & Woldu, Z., 2010. Ethnomedicinal study of plants used by Sheko ethnic group of Ethiopia. Journal of Ethnopharmacology 132(1):75–85.

Gijsbers, H.J.M., Kessler, J.J. & Knevel, M.K., 1994. Dynamics and natural regeneration of woody species in farmed parklands in the Sahel region (Province of Passore, Burkina Faso). Forest Ecology and Management. 64(1): 1–12.

Gillah, P.R., Irle, M.A. & Amartey, S.A., 1998. Sisal fibres as a potential raw material for medium density fibreboard production in Tanzania. Annals of Forestry 6(2): 159–172.

Gillet, H., 1990. Flore et végétation de la réserve de faune de Mahazed Assaid, miméogr. Laboratoire du Muséum National d'Histoire Naturelle, Paris, France. 91 pp.

Gillett, J.B., 1966. Ormocarpum Beauv. & Arthrocarpum Balf.f. (Leguminosae) in south-westen Asia and Africa (excluding Madagascar). Kew Bulletin 20: 323–355.

Gillett, J.B., Polhill, R.M., Verdcourt, B., Schubert, B.G., Milne-Redhead, E., & Brummitt, R.K., 1971. Leguminosae (Parts 3–4), subfamily Papilionoideae (1–2). In: Milne-Redhead, E. & Polhill, R.M. (Editors). Flora of Tropical East Africa. Crown Agents for Oversea Governments and Administrations, London, United Kingdom. 1108 pp.

Gilliland, H.B., 1971. A revised flora of Malaya: an illustrated systematic account of the Malayan flora, including commonly cultivated plants. Vol. 3. Grasses of Malaya. Botanic Gardens, Singapore. pp. 49–51.

Glen, H.F., 2004. Raphia australis Oberm. & Strey. [Internet] South African National Biodiversity Institute, Kirstenbosch, South Africa. <http://www.plantzafrica.com/ plantqrs/ raphiaaust.htm>. Accessed January 2011.

Goetghebeur, P. & Coudijzer, J., 1985. Studies in Cyperaceae 5. The Genus Bulbostylis in Central Africa. Bulletin du Jardin Botanique National de Belgique 55(1–2): 207–259.

Goetghebeur, P. & Simpson, D.A., 1991. Critical notes on Actinoscirpus, Bolboschoenus, Isolepis, Phylloscirpus and Amphiscirpus (Cyperaceae). Kew Bulletin 46(1): 169–178.

Goldsmith, B. & Carter, D.T., 1992. Indigenous timbers of Zimbabwe. The Zimbabwe Bulletin of forestry research No. 9. Forestry Commission. Harare. 406 pp.

Göltenboth, F. & Müller, W., 2010. Abacá – cultivation, extraction and processing. In: Müssig, J. (Editor). Industrial applications of natural fibres: structure, properties and technical applications. John Wiley & Sons, Chichester, United Kingdom. pp. 163–180.

Gonçalves, M.L., 1987. Convolvulaceae. In: Launert, E. (Editor). Flora Zambesiaca. Volume 8, part 1. Flora Zambesiaca Managing Committee, London, United Kingdom. pp. 9–129.

Gonzal, L.R. & Valida, A.F., 2003. Musa textilis Née. In: Brink, M. & Escobin, R.P. (Editors). Plant Resources of South-East Asia No 17. Fibre plants. Backhuys Publishers, Leiden, Netherlands. pp. 186–193.

González, F., 1999. Inflorescence morphology and the systematics of Aristolochiaceae. Systematics and Geography of Plants 68(1–2): 159–172.

Gordon, S. & Hsieh, Y.-L., 2007. Cotton: science and technology. Woodhead Publishing, Cambridge, United Kingdom. 568 pp.

Gordon-Gray, K.D. & Ward, C.J., 1971. A contribution to knowledge of Phragmites (Graminae) in South Africa, with particular reference to Natal populations. South African Journal of Botany 37: 1–30.

Gordon-Gray, K.D., Baijnath, H., Ward, C.J. & Wragg, P.D., 2009. Studies in Cyperaceae in southern Africa 42: pseudo-vivipary in South African Cyperaceae. South African Journal of Botany 75(1): 165–171.

Goteni, S. & Silou, T., 2011. Valorisation des huiles de palmiers Raphias sese et laurentii du Congo-Brazzaville. [Internet]] 16 pp. <http://www.gp3a.auf.org/ IMG/pdf/ Goteni_publi.pdf >. Accessed February 2011.

Gottwald, H. & Parameswaran, N., 1968. Das sekundäre Xylem und die systematische Stellung der Ancistrocladaceae und Dioncophyllaceae. Botanische Jahrbuecher fuer Systematik, Pflanzengeschichte und Pflanzengeographie 88: 49–69.

Goudet, J.P., 1975. Plantations expérimentales d'espèces papetières en Côte d'Ivoire. Bois et Forêts des Tropiques 159: 3–27.

Goudet, J.P., 1980. Plantations expérimentales d'espèces ligneuses a croissance rapide en République Gabonaise. Bois et Forêts des Tropiques 192: 35–60.

Goulding, E., 1917. Cotton and other vegetable fibres: their production and utilisation. John Murray, London, United Kingdom. 231 pp.

Goulding, E., 1937. Textile fibres of vegetable origin: forty years of investigation at the Imperial Institute. Bulletin of the Imperial Institute (London, United Kingdom) 35: 27–56.

Govaerts, R., Frodin, D.G. & Radcliffe-Smith, A., 2000. World checklist and bibliography of Euphorbiaceae (with Pandaceae). Royal Botanic Gardens, Kew, Richmond, United Kingdom. 1620 pp.

Goyder, D.J., 1998. A revision of Pachycarpus E.Mey. (Asclepiadaceae: Asclepiadeae) in tropical Africa with notes on the genus in southern Africa. Kew Bulletin 53(2): 335–374.

Goyder, D.J. & Nicholas, A., 2001. A revision of Gomphocarpus R.Br. (Apocynaceae: Asclepiadeae). Kew Bulletin 56(4): 769–836.

Grace, O.M., Prendergast, H.D.V., Jäger, A.K. & van Staden, J., 2002. Bark medicines in traditional healthcare in KwaZulu-Natal, South Africa: an inventory. South African Journal of Botany 69(3): 301–363.

Gradé, J.T., Tabuti, J.R.S. & van Damme, P., 2009. Ethnoveterinary knowledge in pastoral Karamoja, Uganda. Journal of Ethnopharmacology 122: 273–293.

Graham, J.G., Quinn, M.L., Fabricant, D.S. & Farnsworth, N.R., 2000. Plants used against cancer – an extension of the work of Jonathan Hartwell. Journal of Ethnopharmacology 73(3): 347–377.

Gray, M., undated. Dypsis fibrosa. [Internet] Palm and Cycad Societies of Australia. Milton, Queensland, Australia. <http://www.pacsoa.org.au/ palms/ Dypsis/fibrosa.html>. Accessed September 2010.

Green, M.L., 1925. Species of Grewia described by Bojer. Bulletin of Miscellaneous Information Kew 1925(5): 231–239.

Green, S., Green, T.L. & Heslop-Harrison, Y., 1979. Seasonal heterophylly and leaf gland features in Triphyophyllum (Dioncophyllaceae), a new carnivorous plant genus. Botanical Journal of the Linnean Society 78: 99–116.

Greenway, P.J., 1950. Vegetable fibres and flosses in East Africa. The East African Agricultural Journal 15(3): 146–153.

Greenwood, E.A.N., 1966. The response to nitrogen of two strains of Hyparrhenia hirta under irrigation and defoliation. Field Station Record, Division of Plant Industry, CSIRO 5(1): 29–36.

Grindley, D.N., 1950. The component fatty acids of various Sudan vegetable oils. Journal of the Science of Food and Agriculture 1(5): 152–155.

Grivetti, L.E., Frentzel, C.J., Ginesberg, K.E., Howell, K.L. & Ogle, B.M., 1987. Bush foods and edible weeds of agriculture: Perspectives on dietary use of wild plants in Africa, their role in maintaining human nutritional status and implications for agricultural development. In: Akhtar, R. (Editor). Health and Disease in Tropical Africa. Harwood Academy, New Jersey, United States. pp. 51–81.

Grosvenor, P.W., Gothard, P.K., McWilliam, N.C., Supriono, A. & Gray, D.O., 1995. Medicinal plants from Riau Province, Sumatra, Indonesia. Part I: uses. Journal of Ethnopharmacology 45(2): 75–95.

Grubben, G.J.H., 1977. Tropical vegetables and their genetic resources. IBPGR, Rome, Italy. 197 pp.

Guarte, R.C., 2006. Utilization of abaca (Musa textilis Née) fiber in the automotive industry: the case of the PPP abaca project in the Philippines. Leyte State University, Baybay, Philippines. 33 pp.

Guéneau, P., Bedel, J. & Thiel, J., 1970–1975. Bois et essences malgaches. Centre Technique Forestier Tropical, Nogent-sur-Marne, France. 150 pp.

Gueye, M. & Diouf, M., 2007. Traditional leafy vegetables in Senegal: diversity and medicinal uses. African Journal of Traditional, Complementary and Alternative Medicines 4(4): 469–475.

Guglielmo, A., Pavone, P. & Salmeri, C., 2009. Palms. [Internet] <http://www.dipbot.unict.it/ Palms/index.html>. Accessed October 2009.

Guinko, S., 1997. Rôle des Acacias dans le développement rural au Burkina Faso et au Niger, Afrique de l'Ouest. In: Barreteau, D. & Dognin, R. (Editors). L'homme et le milieu végétal dans le bassin du lac Tchad. Réseau Méga Tchad, Frankfurt, Germany. pp. 35–51.

Gurib-Fakim, A. & Brendler, T., 2004. Medicinal and aromatic plants of Indian Ocean Islands: Madagascar, Comoros, Seychelles and Mascarenes. Medpharm, Stuttgart, Germany. 568 pp.

Gurib-Fakim, A., Guého, J. & Bissoondoyal, M.D., 1995. Plantes médicinales de Maurice, tome 1. Editions de l'Océan Indien, Rose-Hill, Mauritius. 495 pp.

Gurib-Fakim, A., Guého, J. & Bissoondoyal, M.D., 1996. Plantes médicinales de Maurice, tome 2. Editions de l'Océan Indien, Rose-Hill, Mauritius. 532 pp.

Gurib-Fakim, A., Guého, J., Sewraj, M.D. & Dulloo, E., 1994. Plantes médicinales de l'île Rodrigues. Editions de l'Océan Indien, Rose-Hill, Mauritius. 580 pp.

Gutteridge, R.C., 1988. Alley cropping kenaf (Hibiscus cannabinus) with leucaena (Leuceana leucocephala) in south-eastern Queensland, Australia. Australian Journal of Experimental Agriculture 28(4): 481–484.

Gyimah, A., 1997. Germination of Calamus deerratus. Ghana Journal of Forestry 5: 51–56.

Haerdi, F., 1964. Die Eingeborenen-Heilpflanzen des Ulanga-Distriktes Tanganjikas (Ostafrika). In: Haerdi, F., Kerharo, J. & Adam, J.G. (Editors). Afrikanische Heilpflanzen / Plantes médicinales africaines. Acta Tropica Supplementum 8: 1–278.

Haines, R.W. & Lye, K.A., 1983. The sedges and rushes of East Africa: a flora of the families Juncaceae and Cyperaceae in East Africa – with a particular reference to Uganda. East African Natural History Society, Nairobi, Kenya. 404 pp.

Hajaniaina, O.M., 2000. Efficacité du jus mousseux d'Aloès vert et effet répulsif du Buddleja madagascariensis sur les poux de riz. Symposium national sur l'utilisation des produits naturels en protection des végétaux à Madagascar, 29 juin – 3 juillet 1998, Antananarivo, Madagascar. pp. 307–324.

Häkkinen, M. & Väre, H., 2008. Typification and check-list of Musa L. names (Musaceae) with nomenclatural notes. Adansonia sér. 3, 30(1): 63–112.

Hall, J.B., 1980. New and little-known species of Placodiscus (Sapindaceae) in West Africa. Adansonia séries 2, 20(3): 287–295.

Hall, J.B. & Swaine, M.D., 1981. Distribution and ecology of vascular plants in a tropical rain forest: forest vegetation of Ghana. W. Junk Publishers, the Hague, Netherlands. 383 pp.

Hallé, N., 1961. Sterculiacées. Flore du Gabon. Volume 2. Muséum National d'Histoire Naturelle, Paris, France. 150 pp.

Hallé, N., 1962. Monographie des Hippocratéacées d'Afrique occidentale. Mémoires de l' Institut Francais d'Afrique Noire 64: 1–245.

Hallé, N., 1978. Révision monographique des Hippocrateae (Celastr.): 1. Les espèces de Madagascar. Adansonia 17(4): 397–414.

Hallé, N., 1986. Celastraceae, 2ème partie: Hippocrateoideae. Flore du Gabon. Volume 29. Muséum National d'Histoire Naturelle, Paris, France. 287 pp.

Hallé, N., 1990. Celastraceae (Hippocrateoideae). Flore du Cameroun. Volume 32. Muséum National d'Histoire Naturelle, Paris, France. 247 pp.

Hallé, F., Oldeman, R.A.A. & Tomlinson, P.B., 1978. Tropical trees and forests: an architectural analysis. Springer Verlag, Berlin, Germany. 441 pp.

Hambler, D.J., 1961. A poikilohydrous, poikilochlorophyllous angiosperm from Africa. Nature 191: 1415–1416.

Hamill, F.A., Apio, S., Mubiru, N.K., Mosango, M., Bukenya-Ziraba, R., Maganyi, O.W. & Soejarto, D.D., 2000. Traditional herbal drugs of southern Uganda, 1. Journal of Ethnopharmacology 70: 281–300.

Hamill, F.A., Apio, S., Mubiru, N.K., Bukenya-Ziraba, R., Mosango, M., Maganyi, O.W. & Soejarto, D.D., 2003. Traditional herbal drugs of southern Uganda, 2: literature analysis and antimicrobial assays. Journal of Ethnopharmacology 84: 57–78.

Hamza, O.J.M., van den Bout-van den Beukel, C.J.P., Matee, M.I.N., Moshi, M.J., Mikx, F.H.M., Selemani, H.O., Mbwambo, Z.H., van der Ven, A.J.A.M. & Verweij, P.E., 2006. Antifungal activity of some Tanzanian plants used traditionally for the treatment of fungal infections. Journal of Ethnopharmacology 108(1): 124–132.

Handa, S.S., Kinghorn, A.D., Cordell, G.A. & Farnsworth, N.R., 1983. Plant anticancer agents XXVI: Constituents of Peddiea fischeri. Journal of Natural Products 46(2): 248–250.

Hanelt, P. & Institute of Plant Genetics and Crop Plant Research (Editors), 2001. Mansfeld's encyclopedia of agricultural and horticultural crops (except ornamentals). 1st English edition. Springer Verlag, Berlin, Germany. 3645 pp.

Hansen, H.H., Sanou, L. & Nacoulma, B.M.I., 2008. Tree leaves in the diet of free-ranging ruminants in three areas of Burkina Faso. [Internet] Livestock Research for Rural Development 20(3). <http://www.lrrd.org/lrrd20/3/hann20033.htm>. Accessed August 2011.

Hansen, K., Nyman, U., Smitt, U.W., Adsersen, A., Gudiksen, L., Rajasekharan, S. & Pushpangadan, P., 1995. In vitro screening of traditional medicines for anti-hypertensive effect based on inhibition of the angiotensin converting enzyme (ACE). Journal of Ethnopharmacology 48(1): 43–51.

Hanson, S.W., 1977. Local plants of medicinal interest. Part 4: Habropetalum dawei. Chemistry in Sierra Leone 4: 38–40.

Hanson, S.W., Crawford, M. & Thanasingh, D.P.J., 1981. (+)-Isoshinanolone and 2 methylbenzofuran-4-carbaldehyde from the fish-stunning plant Habropetalum dawei. Phytochemistry 20: 1162.

Hardy, M.B. & Camp, K.G.T., undated. Veld in KwaZulu-Natal. Bioresource groups 11, 12 and 15: moist transitional tall grassveld, moist tall grassveld and moist lowland tall grassveld. [Internet] Agricultural Production Guidelines. <http://agriculture.kzntl.gov.za/ publications/production_guidelines/veld_in_natal/ veld_4.6.htm>. Accessed April 2011.

Harkonen, M., Saarimaki, T. & Mwasumbi, L., 1994. Edible and poisonous mushrooms of Tanzania. African Journal of Mycology and Biotechnology 2(2): 99–123.

Harrington, G.N. & Pratchett, D., 1974. Stocking rate trials in Ankole, Uganda. II. Botanical analysis and oesophageal fistula sampling of pastures grazed at different stocking rates. Journal of Agricultural Science 82: 507–516.

Harris, P.J.C., 1981. Seed viability, dormancy, and field emergence of Urena lobata L. in Sierra Leone. Tropical Agriculture 58(3): 205–213.

Harris, P.J.C. & Bindi, F., 1983. Dysdercus spp. as pests of Urena lobata in Sierra Leone. Tropical Pest Management 29(1): 1–6.

Hartemink, A.E., 1997. Input and output of major nutrients under monocropping sisal in Tanzania. Land Degradation & Development 8(4): 305–310.

Hartemink, A.E. & Wienk, J.F., 1995. Sisal production and soil fertility decline in Tanzania. Outlook on Agriculture 24(2): 91–96.

Hasrat, J.A., Pieters, L. & Vlietinck, A. J., 2004. Medicinal plants in Suriname: hypotensive effect of Gossypium barbadense. Journal of Pharmacy and Pharmacology 56: 381–387.

Hatani, A. & Maeda, H., 2004. Cell activator, antioxidant and skincare preparation for external use/Cell activator, antioxidant and skin external preparation containing extract of plant of genus Thelypteris. Japan Kokai Tokkyo Koho (2004), JP 2004083490 A 20040318.

Hattori, S., 2006. Utilization of Marantaceae plants by the Baka hunter-gatherers in southeastern Cameroon. African Study Monographs, Supplement 33: 29–48.

Hau, B., Lançon, J. & Dessauw, D., 1997. Les cotonniers. In: Charrier, A., Jacquot, M., Hamon, S. & Nicolas, D. (Editors): L'amélioration des plantes tropicales. Centre de coopération internationale en recherche agronomique pour le développement (CIRAD) & Institut français de recherche scientifique pour le développement en coopération (ORSTOM), Montpellier, France. pp. 241–265.

Haule, A.T., Pratap, H.B., Katima, H.J.Y., Mbwette, T.S.A. & Njau, K., 2002. Nitrogen removal from domestic wastewater in subsurface flow constructed wetlands by indigenous macrophytes in the tropics. In: Proceedings of 8th International Conference on Wetland Systems for Water Pollution Control. University of Dar es Salaam and IWA, Arusha, Tanzania: 938–951.

Hauman, L., 1948a. Aristolochiaceae. In: Robyns, W., Staner, P., De Wildeman, E., Germain, R., Gilbert, G., Hauman, L., Homès, M., Lebrun, J., Louis, J., Vanden Abeele, M. & Boutique, R. (Editors). Flore du Congo belge et du Ruanda-Urundi. Spermatophytes. Volume 1. Institut National pour l'Étude Agronomique du Congo belge, Brussels, Belgium. pp. 381–389.

Hauman, L., 1948b. Urticaceae. In: Robyns, W., Staner, P., De Wildeman, E., Germain, R., Gilbert, G., Hauman, L., Homès, M., Lebrun, J., Louis, J., Vanden Abeele, M. & Boutique, R. (Editors). Flore du Congo belge et du Ruanda-Urundi. Spermatophytes. Volume 1. Institut National pour l'Étude Agronomique du Congo belge, Brussels, Belgium. pp. 177–218.

Hauman, L., 1960. Sapindaceae. In: Robyns, W., Staner, P., Demaret, F., Germain, R., Gilbert, G., Hauman, L., Homès, M., Jurion, F., Lebrun, J., Vanden Abeele, M. & Boutique, R. (Editors). Flore du Congo belge et du Ruanda-Urundi. Spermatophytes. Volume 9. Institut National pour l'Étude Agronomique du Congo belge, Brussels, Belgium. pp. 279–384.

Hauman, L. & Wouters, W., 1963. Malvaceae. In: Robyns, W., Staner, P., Demaret, F., Germain, R., Gilbert, G., Hauman, L., Homès, M., Jurion, F., Lebrun, J., Vanden Abeele, M. & Boutique, R. (Editors). Flore du Congo belge et du Ruanda-Urundi. Spermatophytes. Volume 10. Institut National pour l'Étude Agronomique du Congo belge, Brussels, Belgium. pp. 92–190.

Hauman, L., Lebrun, J. & Boutique, R., 1948. Moraceae. In: Robyns, W., Staner, P., De Wildeman, E., Germain, R., Gilbert, G., Hauman, L., Homès, M., Lebrun, J., Louis, J., Vanden Abeele, M. & Boutique, R. (Editors). Flore du Congo belge et du Ruanda-Urundi. Spermatophytes. Volume 1. Institut National pour l'Étude Agronomique du Congo belge, Brussels, Belgium. pp. 52–176.

Hauman, L., Cronquist, A., Léonard, J., Schubert, B., Duvigneaud, P. & Dewit, J., 1954. Papilionaceae (deuxième partie). In: Robyns, W., Staner, P., Demaret, F., Germain, R., Gilbert, G., Hauman, L., Homès, M., Jurion, F., Lebrun, J., Vanden Abeele, M. & Boutique, R. (Editors). Flore du Congo belge et du Ruanda-Urundi. Spermatophytes. Volume 5. Institut National pour l'Étude Agronomique du Congo belge, Brussels, Belgium. 377 pp.

Hawthorne, W., 1990. Field guide to the forest trees of Ghana. Natural Resources Institute, for the Overseas Development Administration, London, United Kingdom. 275 pp.

Hawthorne, W.D., 1995. Ecological profiles of Ghanaian forest trees. Tropical Forestry Papers 29. Oxford Forestry Institute, Department of Plant Sciences, University of Oxford, United Kingdom. 345 pp.

Hawthorne, W., 1998. Pteleopsis habeensis. In: IUCN. 2010 Red list of threatened species. Version 2010.1. [Internet] <http://www.iucnredlist.org>. Accessed May 2010.

Hawthorne, W. & Jongkind, C., 2006. Woody plants of western African forests: a guide to the forest trees, shrubs and lianes from Senegal to Ghana. Kew Publishing, Royal Botanic Gardens, Kew, United Kingdom. 1023 pp.

Hearn, D.J., 2006. Adenia (Passifloraceae) and its adaptive radiation: phylogeny and growth form diversification. Systematic Botany 31(4): 805–821.

Hearn, D.J., 2007. Novelties in Adenia (Passifloraceae): four new species, a new combination, a vegetative key, and diagnostic characters for known Madagascan species. Brittonia 59(4): 308 327.

Heckel, E., 1987. Recherches sur les graines grasses nouvelles ou peu connues des colonies françaises. Annales de l'Institut Botanico-Géologique Colonial de Marseille 4: 153–197.

Heckel, E. & Schlagdenhauffen, C.F., 1889. Sur le maloukang ou ankalaki fourni par le Polygala butyracea. Journal de Pharmacie et de Chimie, série 5(20): 148–161, 197–205.

Hedberg, I., Hedberg, O., Madati, P.J., Mshigeni, K.E., Mshiu, E.N. & Samuelsson, G., 1983. Inventory of plants used in traditional medicine in Tanzania. Part III. Plants of the families Papilionaceae-Vitaceae. Journal of Ethnopharmacology 9: 237–260.

Heermans, J.G., 1986. The Guesselbodi experiment: bushland management in Niger. Rural Africana 23/24: 67–77.

Hegnauer, R., 1973. Chemotaxonomie der Pflanzen. Band 6. Birkhäuser Verlag, Basel, Switzerland. 882 pp.

Hegnauer, R., 1986. Chemotaxonomie der Pflanzen. Band 7. Birkhäuser Verlag, Basel, Switzerland. 804 pp.

Hegnauer, R. & Hegnauer, M., 1994. Chemotaxonomie der Pflanzen. Band 11a. Birkhäuser Verlag, Basel, Switzerland. 529 pp.

Hegnauer, R. & Hegnauer, M., 1996. Chemotaxonomie der Pflanzen. Band 11b-1. Birkhäuser Verlag, Basel, Switzerland. 500 pp.

Heim de Balsac, F., Cercelet, M., Maheu, J., Dagand, G.S. & Heim de Balsac, R., 1926. Doum palm (Hyphaene thebaica, Mart.) (as a paper-making material). Bulletin of the Imperial Institute 24: 264–265.

Heine, B. & Heine, I., 1988a. Plant concepts and plant use; an ethnobotanical survey of the semi-arid and arid lands of East Africa. Part 1. Plants of the Chamus (Kenya). Cologne Development Studies 6. Breitenbach, Saarbrücken, Germany. 103 pp.

Heine, B. & Heine, I., 1988b. Plant concepts and plant use; an ethnobotanical survey of the semi-arid and arid lands of East Africa. Part 3. Rendille plants (Kenya). Cologne Development Studies 8. Breitenbach, Saarbrücken, Germany. 120 pp.

Heine, B. & Legère, K., 1995. Swahili plants: an ethnobotanical survey. Rüdiger Köppe Verlag, Köln, Germany. 376 pp.

Heiser, C.B. & Schilling, E.E., 1990. The genus Luffa: A problem in phytogeography. In: Bates, D.M., Robinson, R.W. & Jeffrey, C. (Editors). Biology and utilization of the Cucurbitaceae. Comstock, Cornell University Press, Ithaca, United States. pp. 120–133.

Henderson, A., 2002. Reply to Edwards, P., J. Kollmann & K. Fleischmann. 2003. Life history evolution in Lodoicea maldivica (Arecaceae). Nordic Journal of Botany 22(4): 418.

Hendricksen, R.E., Myles, D.J., Reid, D.J. & Orr, D.M., 2010. Impacts of grazing management options on pasture and animal productivity in a Heteropogon contortus (black speargrass) pasture in central Queensland. 3. Diet composition in autumn. Animal Production Science 50(4): 276–283.

Henrici, A., Kaloga, M. & Eich, E., 1995. 1,2,3,4-Tetrahydro-ß-carboline-3ß-carboxylic acid from Merremia aegyptia L. (Convolvulaceae). Book of Abstracts, 43rd Annual Congress of the Society for Medicinal Plant Research, Halle (Saale), Germany.

Hepper, F.N., 1958. Papilionaceae. In: Keay, R.W.J. (Editor). Flora of West Tropical Africa. Volume 1, part 2. 2nd Edition. Crown Agents for Oversea Governments and Administrations, London, United Kingdom. pp. 505–587.

Hepper, F.N., 1967. Culcasia scandens P.Beauv. (Araceae) and allied species in West Africa. Kew Bulletin 21(2): 315–326.

Hepper, F.N., 1968a. Agavaceae. In: Hepper, F.N. (Editor). Flora of West Tropical Africa. Volume 3, part 1. 2nd Edition. Crown Agents for Oversea Governments and Administrations, London, United Kingdom. pp. 154–159.

Hepper, F.N., 1968b. Araceae. In: Hepper, F.N. (Editor). Flora of West Tropical Africa. Volume 3, part 1. 2nd Edition. Crown Agents for Oversea Governments and Administrations, London, United Kingdom. pp. 112–127.

Hepper, F.N., 1968c. Marantaceae. In: Hepper, F.N. (Editor). Flora of West Tropical Africa. Volume 3, part 1. 2nd Edition. Crown Agents for Oversea Governments and Administrations, London, United Kingdom. pp. 79–89.

Hepper, F.N., 1968d. Notes on Tropical African monocotyledons. 2. Kew Bulletin 22(3): 449–467.

Hepper, F.N., 1972. Juncaceae. In: Hepper, F.N. (Editor). Flora of West Tropical Africa. Volume 3. 2nd Edition. Crown Agents for Oversea Governments and Administrations, London, United Kingdom. pp. 277–278.

Hepper, F.N. & Keay, R.W.J., 1963. Rubiaceae. In: Hepper, F.N. (Editor). Flora of West Tropical Africa. Volume 2. 2nd Edition. Crown Agents for Oversea Governments and Administrations, London, United Kingdom. pp. 104–223.

Hermans, M., Akoègninou, A. & van der Maesen, J., 2004. Medicinal plants used to treat malaria in southern Benin. Economic Botany 58 (supplement): S239–S252.

Herzog, F.M., 1992. Etude biochimique et nutritionnelle des plantes alimentaires sauvages dans le sud du V-Baoulé, Côte d'Ivoire. Ph.D. thesis, Ecole Polytechnique Federale, Zürich, Switzerland. 122 pp.

Herzog, F., Farah, Z. & Amado, R., 1993. Nutritive value of four wild vegetables in Côte d'Ivoire. International Journal for Vitamin and Nutrition Research 63(3): 234–238.

Herzog, F., Gautier-Béguin, F. & Müller, K., 1996. Uncultivated plants for human nutrition in Côte d'Ivoire. In: Leakey, R.R.B., Temu, A.B., Melnyk, M. & Vantomme, P. (Editors). Domestication and commercialization of non-timber forest products in agroforestry systems. Proceedings of an international conference held in Nairobi, Kenya, 19–23 February 1996. FAO, Rome, Italy. pp. 40–50.

Heubl, G., Bringmann, G. & Meimberg, H., 2006. Molecular phylogeny and character evolution of carnivorous plant families in Caryophyllales – revisited. Plant Biology 8(6): 821–830.

Hewlett, B., 1996. Cultural diversity among African Pygmies. In Kent, S. (Editor). Cultural diversity among the twentieth century foragers. Cambridge University Press, Cambridge, United Kingdom. pp. 215–244.

Hibajene, S.H. & Kalumiana, O.S., 2003. Manual for charcoal production in earth kilns in Zambia. [Internet] Department of Energy, Ministry of Energy and Water Development, Lusaka, Zambia & Stockholm Environment Institute, Stockholm, Sweden. 57 pp. <http://www.bioquest.se/ reports/Charcoal%20production%20manual%20ENGLISH.pdf>. Accessed April 2010.

Hickley, P. & Bailey, R.G., 1986. Fish communities in the perennial wetland of the Sudd, southern Sudan. Freshwater Biology 16(5): 695–709.

Hiernaux, P., 1998. Effects of grazing on plant species composition and spatial distribution in rangelands of the Sahel. Plant Ecology 138(2): 191–202.

Hindmarsh, L., 1982. A notebook for Kenyan dyers. National Museum of Kenya, Nairobi, Kenya. 65 pp.

Hnatiuk, R.J., 1980. C4 photosynthesis in the vegetation of Aldabra Atoll. Oecologia 44: 327–334.

Ho, R., Teai, T., Bianchini, J.-P., Lafont, R. & Raharivelomanana, P., 2010. Ferns: from traditional uses to pharmaceutical development, chemical identification of active principles. In: Kumar, A., Fernández, H., & Revilla, M.A. (Editors). Working with ferns Volume 4, Chapter 23. Springer-Verlag, Berlin, Heidelberg, Germany. pp. 321–346.

Hoare, D.B., undated. Trachypogon spicatus (L.f.) Kuntze. [Internet] Grassland species profiles. CIAT/FAO collaboration on tropical forages. <http://www.fao.org/ ag/AGP/agpc/doc/GBASE/data/ pf000395.htm>. Accessed June 2011.

Hochreutiner, B.P.G., 1955. Malvacées (Malvaceae). Flore de Madagascar et des Comores (plantes vasculaires), familles 129–130. Firmin-Didot et cie., Paris, France. 170 pp.

Hodgkin, T., Rana, R., Tuxill, J., Balma, D., Subedi, I., Mar, I., Karamura, D., Valdivia, R., Collado, L., Latournerie, L., Sadiki, M., Sawadogo, M., Brown, A.D.H. & Jarvis, D.I., 2007. Seed systems and crop genetic diversity in agroecosystems. In: Jarvis, D.I., Padoch, C. & Cooper, H.D. (Editors)

Managing biodiversity in agricultural ecosystems. Columbia University Press, New York, United States. pp. 77–116.

Hodkinson, T.R., Chase, M.W., Lledo, M.D., Salamin, N. & Renvoize, S.A., 2002. Phylogenetics of Miscanthus, Saccharum and related genera (Saccharinae, Andropogoneae, Poaceae) based on DNA sequences from ITS nuclear ribosomal DNA and plastid trnL intron and trnL-F intergenic spacers. Journal of Plant Research 115(5): 381–392.

Hoenselaar, K., Verdcourt, B. & Beentje, H.J., 2010. Cyperaceae. In: Beentje, H.J. (Editor). Flora of Tropical East Africa. Royal Botanic Gardens, Kew, Richmond, United Kingdom. 467 pp.

Holm, L.G., Plucknett, D.L., Pancho, J.V. & Herberger, J.P., 1977. The world's worst weeds. Distribution and biology. University Press of Hawaii, Honolulu, United States. 609 pp.

Holttum, R.E., 1971. Studies in the family Thelypteridaceae III. A new system of genera in the old world. Blumea 19: 17–52.

Holttum, R.E., 1977. The family Thelypteridaceae in the Pacific and Australasia. Allertonia 1: 169–243.

Hooker, J.D., 1878. Hooker's Icones Plantarum. Ser. 3, vol. 13(3). Pl. 1251–1275.

Hooper, S.S. & Napper, D.M., 1972. Cyperaceae. In: Hepper, F.N. (Editor). Flora of West Tropical Africa. Volume 3. 2nd Edition. Crown Agents for Oversea Governments and Administrations, London, United Kingdom. pp. 278–348.

Hopkins, B. & Stanfield, D.P., 1966. A field key to the savanna trees of Nigeria. Ibadan, Nigeria. 39 pp.

Hosamani, K.M. & Ramesh, H.S., 2003. Industrial utilization of Triumfetta pilosa, Roth seed oil: a moderate source of oil and cyclopropenoid fatty acids. Industrial Crops and Products 17(1): 53 56.

Hsieh, Y.P. & Weber, O.J., 1984. Net aerial primary production and dynamics of soil organic matter formation in a tidal marsh ecosystem. Soil Science Society of America Journal 48: 65–72.

Hsu, B., Coupar, I.M. & Ng, K., 2006. Antioxidant activity of hot water extract from the fruit of doum palm, Hyphaene thebaica. Food Chemistry 98(2): 317–328.

Huang, K.-L., Lai, Y.-K., Lin, C.-C. & Chang, J.-M., 2006. Inhibition of hepatitis B virus production by Boehmeria nivea root extract in HepG2 2.2.15 cells. World Journal of Gastroenterology 12(35): 5721–5725.

Hubbard, C.E., 1949. Notes on African Grasses: XXIII. Kew Bulletin 4(3): 341–376.

Huber, H., 1963. Apocynaceae. In: Hepper, F.N. (Editor). Flora of West Tropical Africa. Volume 2. 2nd Edition. Crown Agents for Oversea Governments and Administrations, London, United Kingdom. pp. 51–80.

Huber, H., 1985. Samenmerkmale und Gliederung der Aristolochiaceen. Botanische Jahrbücher für Systematik, Pflanzengeschichte und Pflanzengeographie 107: 277–320.

Huber, H., 1993. Aristolochiaceae. In: Kubitzki, K., Rohwer, J.G. & Bittrich, V. (Editors). The families and genera of vascular plants. Volume 2, Flowering plants- Dicotyledons. Magnoliid, Hamamelid and Caryophyllid families. Springer, Berlin, Germany. pp. 129–137.

Hul, S., 1995. Flacourtiaceae. Flore du Gabon. Volume 34. Muséum National d'Histoire Naturelle, Paris, France. 82 pp.

Hunter, R.A. & Siebert, B.D., 1986. The effects of genotypes, age, pregnancy, lactation and rumen characteristics on voluntary intake of roughage diets by cattle. Australian Journal of Agricultural research 37(5): 549–560.

Hussain, H.E.M.A., Jamil, K. & Rao, M., 2001. Preliminary studies on the hypoglycaemic effect of Abroma augusta in alloxan diabetic rats. Indian. Journal of Clinical Biochemistry16(1): 77– 80.

Hutchings, A., Haxton Scott, A., Lewis, G. & Cunningham, A., 1996. Zulu medicinal plants: an inventory. University of Natal Press, Pietermaritzburg, South Africa. 450 pp.

Hutchinson, J., 1962. The history and relationships of the world's cottons. Endeavour 21: 5–15.

Hutchinson, J., 1963. Oncocalamus wrightianus. Kew Bulletin 17: 181.

Hutchinson, J. & Dalziel, J.M., 1928a. Tropical African Plants II. Bulletin of Miscellaneous Information Kew 1928(1): 22–32.

Hutchinson, J. & Dalziel, J.M., 1928b. Tropical African plants: IV. Bulletin of Miscellaneous Information Kew 1928(7): 296–301.

Huttel, C., Touber, L. & Clüsener-Godt, M., 2002. La Réserve de Biosphère de Mananara-Nord: un défi pour la conservation et le développement intégrés. MAB-UNESCO & ANGAP, Antananarivo, Madagascar. 188 pp.

Huxley, A. (Editor), 1992a. The new Royal Horticultural Society dictionary of gardening. Volume 1. MacMillan Press, London, United Kingdom. 815 pp.

Huxley, A. (Editor), 1992b. The new Royal Horticultural Society dictionary of gardening. Volume 2. MacMillan Press, London, United Kingdom. 747 pp.

Huxley, A. (Editor), 1992c. The new Royal Horticultural Society dictionary of gardening. Volume 3. MacMillan Press, London, United Kingdom. 790 pp.

Huynh, K.-L., 1977. L'appareil mâle de quelques Pandanus du sous-genre Vinsonia (Pandanaceae) et sa signification taxonomique, phylogénique et évolutive. Beiträge zur Biologie der Pflanzen 53(3): 447–471.

Huynh, K.-L., 1979. La morphologie microscopique de la feuille et la taxonomie du genre Pandanus. 6. P. subg. Vinsonia et P. subg. Martellidendron. 2. Considérations sur P. subg. Vinsonia. Botanische Jahrbücher für Systematik, Pflanzengeschichte und Pflanzengeographie 100(4): 473–517.

Huynh, K.-L., 1987. Etude des Pandanus (Pandanaceae) d'Afrique occidentale (3e partie): une espèce nouvelle du Ghana. Botanica Helvetica 97(1): 81–88.

Huynh, K.-L., 1988. Etude des Pandanus (Pandanaceae) d'Afrique occidentale (11ième partie): espèces nouvelles de la Sierra Leone. Botanica Helvetica 98(2): 171–194.

Huynh, K.-L., 1989. Le problème de l'identité de Pandanus candelabrum P. Beauv. (Pandanaceae), et l'étude taxonomique de ce genre en Afrique occidentale. Quelques suggestions pour des récoltes optimales de matériel taxonomique de Pandanus, en particulier d'Afrique occidentale. Candollea 44(1): 59–74.

Huynh, K.-L., 1991. Etude des Pandanus (Pandanaceae) d'Afrique occidentale (12e partie): espèces nouvelles du Cameroun. Botanica Helvetica 101(2): 247–257.

Hyde, M. & Wursten, B., 2002. Ficus bussei Mildbr. & Burret. [Internet] Flora of Zimbabwe. <http://www.zimbabweflora.co.zw/ speciesdata/ species.php?species_id=120230>. Accessed June 2009.

Hyde, M. & Wursten, B., 2006. Abutilon angulatum (Guill. & Perr.) Mast. var. angulatum. [Internet] Flora of Zimbabwe. <http://www.zimbabweflora.co.zw/speciesdata/species.php?species_id=138810>. Accessed November 2009.

Hyde, M.A. & Wursten, B., 2009a. Thymelaeaceae. [Internet] Flora of Zimbabwe. <http://www.zimbabweflora.co.zw/ speciesdata/ family.php?family_id=220>. Accessed February 2009.

Hyde, M.A. & Wursten, B., 2009b. Urticaceae. [Internet] Flora of Zimbabwe. <http://www.zimbabweflora.co.zw/ speciesdata/ family.php?family_id=227>. Accessed March 2009.

Hyde, M.A. & Wursten, B., 2009c. Velloziaceae. [Internet] Flora of Zimbabwe. <http://www.zimbabweflora.co.zw/ speciesdata/ family.php?family_id=230>. Accessed Februari 2009.

Hyde, M.A. & Wursten, B., 2011. Pedaliaceae. [Internet] Flora of Zimbabwe: Family page. <http://www.zimbabweflora.co.zw/ speciesdata/ family.php?family_id=168>. Accessed September 2011.

Ibaragi, Y., 2004. Miscanthidium junceum subsp. teretifolium (Poaceae); a new combination for an African grass. Journal of Phytogeography and Taxonomy 52: 175–178.

Ibewuike, J.C., Ogundaini, A.O., Ogungbamila, F.O., Martin, M.-T., Gallard, J.-F., Bohlin, L. & Pais, M., 1996. Piliostigmin, a 2-phenoxychromone, and C-methylflavonols from Piliostigma thonningii. Phytochemistry 43(3): 687–690.

Ibewuike, J.C., Ogungbamila, F.O., Ogundaini, A.O., Okeke, I.N. & Bohlin, L., 1997. Antiinflammatory and antibacterial activities of C-methylflavonols from Piliostigma thonningii. Phytotherapy Research 11(4): 281–284.

Ibrahim, A.A.M. & Aref, I.M., 2000. Host status of thirteen Acacia species to Meloidogyne javanica. Journal of Nematology 32(4S): 609–613.

Ibrahim, N., Shalaby, A.S., El-Gengaihi, S. & Rizk, M., 1999. Antitumor activity of proteins and polysaccharides of certain cucurbitaceous plants. Acta Horticulturae 501: 37–43.

ICAC, 2008. Cotton production practices. International Cotton Advisory Committee, Washington D.C., United States.

Ichikawa, M., 1987. A preliminary report on the ethnobotany of the Suiei Dorobo in northern Kenya. African Study Monographs, Supplement 7: 1–52.

Idu, M., Ijomah, J.U. & Omonhinmin, A.C., 2002. Histomorphology of the tracheary elements of some Fabaceae hardwood. Discovery and Innovation 14(1–2): 46–50.

Idu, M., Obaruyi, G.O. & Erhabor, J.O., 2008. Ethnobotanical uses of plants among the Binis in the treatment of ophthalmic and ent (ear, nose and throat) ailments. Ethnobotanical Leaflets 13: 480.

IENICA, 2007. Sisal. IENICA crops database. [Internet]. Interactive European Network for Industrial Crops and their Applications. <http://ienica.net/ cropsdatabase.htm>. Accessed September 2011.

Igoli, J.O., Igwue, I.C. & Igoli, N.P., 2003. Traditional medicinal practices among the Igede people of Nigeria. Journal of Herbs, Spices and Medicinal Plants 10(4): 1–10.

Igoli, J.O., Ogaji, O.G., Tor-Anyiin, T.A. & Igoli, N.P., 2005. Traditional medicine practice amongst the Igede people of Nigeria. Part 2. African Journal of Traditional, Complementary and Alternative Medicines 2(2): 134–152.

Igwenyi, I.O., Njoku, O.U., Ikwuagwu, O.E. & Nwuke, C.P., 2008. Extraction, characterization and potentials of raphia mesocarp oil for the production of biodiesel. Journal of Agriculture, Biotechnology and Ecology1(1): 53–61.

Ihlenfeldt, H.-D., 1988. Pedaliaceae. In: Launert, E. (Editor). Flora Zambesiaca. Volume 8, part 3. Flora Zambesiaca Managing Committee, London, United Kingdom. pp. 86–113.

Ikewuchi, C.C., 2010. Effect of aqueous extract of Sansevieria senegambica Baker on plasma chemistry, lipid profile and atherogenic indices of alloxan treated rats: implications for the management of cardiovascular complications in diabetes mellitus. Pacific Journal of Science and Technology 11(2): 524–531.

Ikitoo, E.C., 1997. Review of Kenyan agricultural research. Vol. 19. Fibre crops. Kenya Agricultural Research Institute (KARI), Nairobi, Kenya. 72 pp.

Ikusima, I., 1978. Primary production and population ecology of the aquatic sedge Lepironia articulata in a tropical swamp, Tasek Bera, Malaysia. Aquatic Botany 4: 269–280.

ILDIS, 2005. World database of Legumes, Version 10,01. International Legume Database & Information Service. [Internet] <http://www.ildis.org/>. Accessed April 2011.

Ilvessalo-Pfäffli, M.-S., 1995. Fiber atlas. Identification of papermaking fibers. Springer Verlag, Berlin, Germany. 400 pp.

Imamura-Hayaki, K., 1996. Gathering activity among the Central Kalahari San. African Study Monographs, Supplement 22: 47–66.

Inderjit, Dakshini, K.M.M. & Foy, C.L., 1999. Principles and practices in plant ecology: allelochemical reactions. CRC Press, Boca Raton, Florida, United States. 589 pp.

InDG, 2011. Cotton. [Internet] India Development Gateway, Centre for Development of Advanced Computing, Jawaharlal Nehru Technological University Campus, Kukatpally, Hyderabad. <http://www.indg.in/ agriculture/agricultural-best-practices/ organic-production/cotton>. Accessed September 2011.

Innes, R.R., 1977. A manual of Ghana grasses: with a key to the species by W.D. Clayton. Ministry of Overseas Development, Surbiton, United Kingdom. 265 pp.

Inngjerdingen, K., Nergård, C.S., Diallo, D., Mounkoro, P.P. & Paulsen, B.S., 2004. An ethnopharmacological survey of plants used for wound healing in Dogonland, Mali, West Africa. Journal of Ethnopharmacology 92: 233–244.

InsideWood, undated. [Internet] <http://insidewood.lib.ncsu.edu/search/>. Accessed May 2007 - August 2011.

IPK, undated. Mansfeld's world encyclopedia of agricultural and horticultural crops. [Internet] Leibnitz Institute of Plant Genetics and Crop Plant Research (IPK), Gatersleben, Germany. <http://mansfeld.ipk-gatersleben.de/ pls/htmldb_pgrc/ f?p=185:3:8208035903155>. Accessed October 2009 - August 2011.

Ipulet, P., 2007. Uses of genus Ficus (Moraceae) in Buganda region, central Uganda African. Journal of Ecology 45(Suppl. 3): 44–47.

Iremiren, G.O. & Onwubuya, I.I., 1985. Growth of Raphia nursery seedlings as affected by spacing, embryo orientation at sowing, shading and irrigation. Journal of the Nigerian Institute for Oil Palm Research 7(1): 76–85.

Irish, J., undated. Namibian Biodiversity Database. [Internet] <http://www.biodiversity.org.na/index.php> Accessed March 2009.

Irobi, O.N. & Adedayo, O., 1999. Antifungal activity of aqueous extract of dormant fruits of Hyphaene thebaica (Palmae). Pharmaceutical-Biology 37(2): 114–117.

Irvine, F.R., 1952. Supplementary and emergency food plants of West Africa. Economic Botany 6: 23–40.

Irvine, F.R., 1961. Woody plants of Ghana, with special reference to their uses. Oxford University Press, London, United Kingdom. 868 pp.

ISAAA, 2011. ISAAA Brief 42–2010: executive summary. [Internet] International Service for the Acquisition of Agri-Biotech Applications, Manila, the Philippines. <http://www.isaaa.org/ resources/publications/briefs/42/ executivesummary/default.asp>. Accessed September 2011.

Isawumi, M.A., 2008. The status of generic revision in the African Vernonieae (Asteraceae). Compositae Newsletter 46: 27–48.

Ishengoma, R.C. & Chihongo, A.W., 1995. Strength properties of lesser known Brachystegia species from miombo woodlands of Tanzania. Commonwealth Forestry Review 74(2): 155–157.

Islam, A.S., Haque, M. & Haque, M.S., 1980. Fibre-bearing potentiality of two jute hybrids. Indian Journal of Genetics and Plant Breeding 40(3): 578–580.

Itabashi, M., Segawa, K., Ikeda, Y., Kondo, S., Naganawa, H., Koyano, T. & Umezawa, K., 2000. A new bioactive steroidal saponin, furcreastatin, from the plant Furcraea foetida. Carbohydrate Research 323(1–4): 57–62.

ITTO, 2001. Tropical timber market report, 1–15 February 2005. International Tropical Timber Organization, Yokohama, Japan.

Ivey, C.T. & Richards, J.H., 2001. Genotypic diversity and clonal structure of Everglades sawgrass, Cladium jamaicense (Cyperaceae). International Journal of Plant Sciences 162(6): 1327–1335.

Jackson, J.K., Taylor, G.F. & Conde-Wane, C., 1983. Gestion des ressources forestières naturelles dans la région du Sahel. OECD, Paris, France. 114 pp.

Jacobs, M.R., 1981. Eucalypts for planting. 2nd Edition. FAO Forestry Series No 11. Food and Agriculture Organization of the United Nations, Rome, Italy. 677 pp.

Jacques, F.M.B., 2009. Survey of the Menispermaceae endocarps. Adansonia, séries 3, 31(1): 47–87.

Jacques-Félix, H., 1935. Recherches de cultures annexes à la culture bananière pour la Guinée Française. Deux plantes à fibres. Revue de Botanique Appliquée & d'Agriculture Tropicale 15: 243–251.

Jacques-Félix, H., 1950. Notes sur les Graminees d'Afrique tropicale X. Revue de Botanique Appliquée. 30: 167–187.

Jacques-Félix, H., 1972. Observations sur les Loudetia annuels du Tchad, du Cameroun et de République Centrafricaine. Adansonia 12(2): 231–243.

Jacques-Félix, H. & Rabéchault, H., 1948. Recherches sur les fibres de quelques Urticacées Africaines. Agronomie Tropicale 3: 339–384, 451–488.

Jäger, A.K., Mohoto, S.P., van Heerden, F.R. & Viljoen, A.M., 2005. Activity of a traditional South African epilepsy remedy in the GABA-benzodiazepine receptor assay. Journal of Ethnopharmacology 96 (3): 603–606.

Jagtap, S.D., Deokule, S.S. & Bhosle, S.V., 2006. Some unique ethnomedicinal uses of plants used by the Korku tribe of Amravati district of Maharashtra, India. Journal of Ethnopharmacology 107(3): 463–469.

Jahiel, M., 1993. Le palmier doum: Hyphaene thebaica (L.) (Mart.). Le Flamboyant 28: 4–10.

Jainu, M. & Devi, C.S.S., 2005. In vitro and in vivo evaluation of free-radical scavenging potential of Cissus quadrangularis. Pharmaceutical Biology 43(9): 773–779.

Janick, J. & Paull, R.E. (Editors), 2006. Encyclopedia of fruit and nuts. CABI, Wallingford, United Kingdom. 954 pp.

Jansen, P.C.M., 1981. Spices, condiments and medicinal plants in Ethiopia, their taxonomy and agricultural significance. Agricultural Research Reports 906. Centre for Agricultural Publishing and Documentation, Wageningen, Netherlands. 327 pp.

Jansen, P.C.M., 2005. Diospyros loureiriana G.Don. [Internet] Record from Protabase. Jansen, P.C.M. & Cardon, D. (Editors). PROTA (Plant Resources of Tropical Africa / Ressources végétales de l'Afrique tropicale), Wageningen, Netherlands. <http://database.prota.org/ search.htm>. Accessed April 2010.

Jansen, P.C.M. & Brink, M., 2003. Schoenoplectus (Rchb.) Palla. In: Brink, M. & Escobin, R.P. (Editors). Plant Resources of South-East Asia No 17. Fibre plants. Backhuys Publishers, Leiden, Netherlands. pp. 221–224.

Jansen, G.J., Gildemacher, B.H. & Phuphathanaphong, L., 1993. Luffa P. Miller. In: Siemonsma, J.S. & Kasem Piluek (Editors). Plant Resources of South-East Asia No 8. Vegetables. Pudoc Scientific Publishers, Wageningen, Netherlands. pp. 194–197.

Jansen, O., Angenot, L., Tits, M., Nicolas, J.-P., De Mol, P., Sacré, P.-Y., Jonville, M.C. & Frédérich, M., 2008. In vitro antiplasmodial activity of ethnobotanically selected plants from Burkina Faso. Planta Medica 74(9): 1142.

Jarman, C., 1998. Plant fibre processing. A handbook. Intermediate Technology Publications, London, United Kingdom. 52 pp.

Jarman, C.G. & Kirby, R.H., 1954. Abutilon longicuspe fibre from Kenya. Colonial Plant and Animal Products 4: 329–330.

Jarolímová, V. & Hroudová, Z., 1998. Chromosome numbers within the genus Bolboschoenus in Central Europe. Folia Geobotanica 33(4): 415–428.

Jeffrey, C., 1965. Key to the Cucurbitaceae of West Tropical Africa, with a guide to localities of rare and little-known species. Journal of the West African Science Association 9: 79–97.

Jeffrey, C., 1967. Cucurbitaceae. In: Milne-Redhead, E. & Polhill, R.M. (Editors). Flora of Tropical East Africa. Crown Agents for Oversea Governments and Administrations, London, United Kingdom. 157 pp.

Jeffrey, C., 1995. Cucurbitaceae. In: Edwards, S., Mesfin Tadesse & Hedberg, I. (Editors). Flora of Ethiopia and Eritrea. Volume 2, part 2. Canellaceae to Euphorbiaceae. The National Herbarium, Addis Ababa University, Addis Ababa, Ethiopia and Department of Systematic Botany, Uppsala University, Uppsala, Sweden. pp. 17–59.

Jeffrey, C. & de Wilde, W.J.J.O., 2006. A review of the subtribe Thladianthinae (Cucurbitaceae). Botanicheskii Zhurnal (Moscow & Leningrad) 91: 766–776.

Jelager, L., Gurib-Fakim, A. & Adsersen, A., 1998. Antibacterial and antifungal activity of medicinal plants of Mauritius. Pharmaceutical Biology 36(3): 153–161.

Jernander, J., 1940. Pratique de la préparation des fibres d'Urena lobata et de Cephalonema. Revue internationale de botanique appliquée et d'agriculture tropicale 228/229: 636–639.

Jeruto, P., Lukhoba, C., Ouma, G., Otieno, D. & Mutai, C., 2008. Herbal treatments in Aldai and Kaptumo divisions in Nandi district, Rift Valley province, Kenya. African Journal of Traditional, Complementary and Alternative Medicines 5(1): 103–105.

Jia, L., Guo, H.B., Jing, L.L., Zhou, S.G. & Kong, D.Y., 2009a. Study on chemical constituents of Urena lobata L. 2. Phenolic acid constituents. Zhongguo Yiyao Gongye Zazhi 40(10): 746–749.

Jia, L., Jing, L.L., Zhou, S.G., A, Y.M. & Kong, D.Y., 2009b. Study on chemical constituents of Urena lobata L. 1. Flavonoid constituents. Zhongguo Yiyao Gongye Zazhi 40(9): 662–665, 704.

Jimoh, F.O. & Oladiji, A.T., 2005. Preliminary Studies on Piliostigma thonningii seeds: proximate analysis, mineral composition and phytochemical screening. African Journal of Biotechnology 4(12): 1439–1442.

Jiofack, T., Fokunang, C., Kemeuze, V., Fongnzossie, E., Tsabang, N., Nkuinkeu, R., Mapongmetsem, P.M. & Nkongmeneck, B.A., 2008. Ethnobotany and phytopharmacopoea of the South-West ethnoecological region of Cameroon. Journal of Medicinal Plants Research 2(8): 197 206.

Jiofack, T., Fokunang, C., Guedje, V., Kemeuze, V., Fongnzossie, E., Nkongmeneck, B.A., Mapongmetsem, P.M. & Tsabang, N., 2009. Ethnobotanical uses of some plants of two ethnoecological regions of Cameroon. African Journal of Pharmacy and Pharmacology 3(13): 664–684.

JIRCAS, 2005–2009. Fakara plants - A database of the plants of the Sahel -. [Internet] <http://www.jircas.affrc.go.jp/ project/africa_dojo/FakaraPlants/ Fakara_Plants_home.html>. Accessed May 2011.

Jirikasem, S., Limsiriwong, P., Kajsongkarm, T. & Soontorntanasart, T., 2000. Phytochemical study of Cissus quadrangularis Linn. Thai Journal of Pharmaceutical Science: 24–25.

Joffe, P., 2001. Creative gardening with indigenous plants. A South African guide. Briza Publications, Pretoria, South Africa. 372 pp.

Joffe, P., 2003. Easy guide to indigenous shrubs. Briza Publications, Pretoria, South Africa. 128 pp.

Johnson, D., 1998a. Dypsis crinita. In: IUCN. 2010 Red list of threatened species. Version 2010.3. [Internet] <http://www.iucnredlist.org>. Accessed September 2010.

Johnson, D., 1998b. Dypsis perrieri. In: IUCN. 2010 Red list of threatened species. Version 2010.3. [Internet] <http://www.iucnredlist.org>. Accessed September 2010.

Johnson, D., 1998c. Livistona carinensis. In: IUCN. 2010 Red list of threatened species. Version 2010.3. [Internet] <http://www.iucnredlist.org>. Accessed October 2010.

Johnson, D.V., 1998d. Palms. Non-wood forest products No 10. FAO, Rome, Italy. 166 pp.

Johnson, J.E. & Delgado, O.J., 2003. Farmer perspectives on agroforestry opportunities and constraints in Cape Verde. Small-scale Forest Economics, Management and Policy 2(3): 343–355.

Johnson, E.J. & Johnson, T.J., 1976. Economic plants in a rural Nigerian market. Economic Botany 30: 375–381.

Johnson, D., Johnson, S. & Nichols, G., 2002. Gardening with indigenous shrubs. Struik Publishers, Cape Town, South Africa. 112 pp.

Jones, M.B., 1988. Photosynthetic responses of C3 and C4 wetland species in a tropical swamp. Journal of Ecology 76: 253–262.

Jones, D.R., 2003. Plant viruses transmitted by whiteflies. European Journal of Plant Pathology 109: 195–219.

Jones, M.B. & Humphries, S.W., 2002. Impacts of the C4 sedge Cyperus papyrus L. on carbon and water fluxes in an African wetland. Hydrobiologia 488: 107–113.

Jones, M.B. & Muthuri, F.M., 1985. The canopy structure and microclimate of papyrus (Cyperus papyrus) swamps. Journal of Ecology 73 (2): 481–491.

Jones, M.B. & Muthuri, E.M., 1997. Standing biomass and carbon distribution in a papyrus (Cyperus papyrus L.) swamp on Lake Naivasha, Kenya. Journal of Tropical Ecology 13(3): 347–356.

Jongkind, C.C.H., 1990. Novitates gabonenses: 2. A new species of Aristolochia and some critical observations on Aristolochia versus Pararistolochia. Bulletin du Jardin Botanique National de Belgique 60(1–2): 147–150.

Jongkind, C.C.H., 2007. The botanical diversity of the Atewa Range. In: McCullough, J. Alonzo, L.E., Naskrecki, P., Wright, H.E. & Osei-Owusu, Y. (Editors). A rapid biological assessment of the Atewa Range Forest Reserve, eastern Ghana. RAP Bulletin of Rapid Biological Assessment 47: 41–43.

Jongkind, C.H., 2008. Two new species of Hypselodelphys (Marantaceae) from West Africa. Adansonia 30(1): 57–62.

Juliana Jonathan & Bambang P.J. Hariadi, 1999. Imperata Cirillo. In: de Padua, L.S., Bunyapraphatsara, N. & Lemmens, R.H.M.J. (Editors). Plant Resources of South-East Asia No 12(1). Medicinal and poisonous plants 1. Backhuys Publishers, Leiden, Netherlands. pp. 307–311.

Jumelle, H., 1945. Palmiers (Palmae). Flore de Madagascar et des Comores (plantes vasculaires), famille 30. Imprimerie Officielle, Tananarive, Madagascar. 180 pp.

Jung, J. & Choi, H.-K., 2010. Systematic rearrangement of Korean Scirpus L. s.l. (Cyperaceae) as inferred from nuclear ITS and chloroplast rbcL sequences. Journal of Plant biology 53: 222–232.

Jurasek, P., Kosik, M. & Phillips, G.O., 1993. A chemometric study of the Acacia (gum arabic) and related natural gums. Food Hydrocolloids 7(1): 73–85.

Kabambe, V., Katunga, L., Kapewa, T. & Ngwira, A.R., 2008. Screening legumes for integrated management of witchweeds (Alectra vogelii and Striga asiatica) in Malawi. African Journal of Agricultural Research 3(10): 708–715.

Kabele Ngiefu, C., Paquot, C. & Vieux, A., 1976. Les plantes à huile du Zaire. 2. Familles botaniques fournissant des huiles d'insaturation moyenne. Oléagineux 31(12): 545–547.

Kaggwa, R.C., Mulalelo, C.I., Denny, P. & Okurut, T.O., 2001. The impact of alum discharges on a natural tropical wetland in Uganda. Water Research 35(3): 795–807.

Kahn, F., 2008. Doum palm habit and leaf collecting practices in Niger. Palms 52(1): 23–29.

Kakudidi, E.K., 2004. Cultural and social uses of plants from and around Kibale National Park, Western Uganda. African Journal of Ecology 42: 114–118.

Kalanda, K. & Bolamba, K., 1994. Contribution à la connaissance des plantes médicinales du Haut Zaïre. Les plantes utilisées contre les maladies de la peau à Kisangani. Revue de Médecines et Pharmacopées Africaines 8(2): 179–188.

Kalanda, K. & Omasombo, W.D., 1995. Contribution à la connaissance des plantes médicinales du Haut-Zaïre - Plantes utilisées dans le traitement des maux d'estomac dans la ville de Kisangani. Revue de Médecines et Pharmacopées Africaines 9(1): 59–69.

Kalanda, K., Ataholo, M. & Ilumbe, B., 1995. Contribution à la connaissance des plantes médicinales du Haut-Zaïre: plantes antihémorroïdaires de Kisangani. Revue de Médecines et Pharmacopées Africaines 9(1): 51–58.

Kamara, C.S. & Maghembe, J.A., 1994. Performance of multipurpose tree and shrub species 28 months after planting at Chalimbana, Zambia. Forest Ecology and Management 64(2–3): 145–151.

Kamatenesi-Mugisha, M. & Oryem-Origa, H., 2007. Medicinal plants used to induce labour during childbirth in western Uganda. Journal of Ethnopharmacology 109: 1–9.

Kamatenesi-Mugisha, M., Makawiti, D.W., Oryem-Origa, H., Olwa-Odyek & Nganga, J., 2007. The oxytocic properties of Luffa cylindrica (L.) M. Roem. and Bidens pilosa L., traditionally used medicinal plants from western Uganda. African Journal of Ecology 45(Suppl. 3): 88–93.

Kamau, C.G., 2009. Constructed wetlands: potential for their use in treatment of grey water in Kenya. M.Sc. Thesis, Christian Albrechts Universität, Kiel, Germany. 77 pp.

Kambewa, P.S., Mataya, B.F., Sichinga, W.K. & Johnson, T.R., 2007. Charcoal, the reality: a study of charcoal consumption, trade and production in Malawi. Small and Medium Forestry Enterprise Series No 21. IIED, London, United Kingdom. 60 pp.

Kambizi, L. & Afolayan, A.J., 2001. An ethnobotanical study of plants used for the treatment of sexually transmitted diseases (njovhera) in Guruve District, Zimbabwe. Journal of Ethnopharmacology 77: 5–9.

Kambu, K., Tona, L., Luki, N., Cimanga, K. & Makuba, W., 1989. Evaluation de l'activité antimicrobienne de quelques préparations traditionelles antidiarrheiques utilisées dans la ville de Kinshasa - Zaire. Médecine Traditionelle et Pharmacopée 3(1): 15–24.

Kammacher, P., Anoma, G., Adjanohoun, E. & Aké Assi, L., 1973. Nombres chromosomiques de Graminées de Côte d'Ivoire. Candollea 28(2): 191–217.

Kankam, C.K. & Odum-Ewuakye, B., 2006. Babadua reinforced concrete two-way slabs subjected to concentrated loading. Construction and Building Materials 20(5): 279–285.

Kanth, V.R. & Diwan, P.V., 1999. Analgesic, antiinflammatory and hypoglycaemic activities of Sida cordifolia. Phytotherapy Research 13(1): 75–77.

Kanyomeka, L., 2003. Survey of weeds and frequency of weeding in pearl millet (Pennisetum glaucum) in North-Central Namibia. Agricultura Tropica et Subtropica 36: 60–64.

Kanzila, M., 1994. La prospection des ligneux fourragers dans la Communauté économique des Pays des Grands Lacs (Burundi, Rwanda, Zaïre). Revue d'élevage et de médecine vétérinaire des pays tropicaux 47(4): 415–424.

Kareru, P.G., Kenji, G.M., Gachanja, A.N., Keriko, J.M. & Mungai, G., 2007. Traditional medicines among the Embu and Mbeere peoples of Kenya. African Journal of Traditional, Complementary and Alternative Medicines 4(1): 75–86.

Karmann, M., 2003. Miombo utilization by small scale farmers in Handeni/Tanzania: bark harvesting as an example for ethnic and gender oriented work. In: FAO/ECE/ILO Commitee on Forest Technology, Management and Training. Harvesting of non-wood forest products. Proceedings of the Seminar on Harvesting of Non-wood Forest Products, 2–8 October 2000, International Agro-Hydrology Research and Training Center, Menemen-Izmir (Turkey). FAO, Rome, Italy.

Karue, C.N., 1974. The nutritive value of herbage in semi-arid lands of East Africa. 1. Chemical composition. East African Agricultural and Forestry Journal 40: 89–95.

Kaseva, M.E., 2004. Performance of a sub-surface flow constructed wetland in polishing pre treated wastewater-a tropical case study. Water Research 38(3): 681–687.

Katende, A.B., Birnie, A. & Tengnäs, B., 1995. Useful trees and shrubs for Uganda: identification, propagation and management for agricultural and pastoral communities. Technical Handbook 10. Regional Soil Conservation Unit, Nairobi, Kenya. 710 pp.

Katende, A.B., Ssegawa, P. & Birnie, A., 1999. Wild food plants and mushrooms of Uganda. Technical Handbook No 19. Regional Land Management Unit/SIDA, Nairobi, Kenya. 490 pp.

Kativu, S., 2001. Asphodelaceae. In: Pope, G.V. (Editor). Flora Zambesiaca. Volume 12, part 3. Royal Botanic Gardens, Kew, Richmond, United Kingdom. pp. 25–48.

Katsenovich, Y.P., Hummel-Batista, A., Ravinet, A.J. & Miller, J.F., 2009. Performance evaluation of constructed wetlands in a tropical region. Ecological Engineering 35: 1529–1537.

Kawukpa, U.U. & Angoyo, M.M., 1994. Plantes utiles chez les Batiabetuwa de l'Ile de Mbie, Kisangani, Zaire. African Study Monographs 15(2): 49–68.

Kay, J.M., 1994. Dietary pulmonary hypertension. Thorax 49: S33–S38.

Kayang, H., 2007. Tribal knowledge on wild edible plants of Meghalaya, Northeast India. Indian Journal of Traditional Knowledge 6(1): 177–181.

Kayode, J., Ige, O.E. & Ojo, B.M., 2009. Conservation and biodiversity erosion in Ondo State, Nigeria: (2). assessing botanicals used in the storage of farm produce in Akure region. Ethnobotanical Leaflets 13: 603–610.

Kayumba, A., Moen, B.E., Bråtveit, M., Eduard, W. & Mashalla, Y., 2011. Workplace: reduced lung function among sisal processors. Occupational and Environmental Medicine 68: 682–685.

Keane, P.J., Kile, G.A., Podger, F.D. & Brown, B.N. (Editors), 2000. Diseases and pathogens of eucalypts. CSIRO Publishing, Collingwood, Australia. 565 pp.

Keay, R.W.J., 1952. Revision of the Flora of West Tropical Africa, 1. Kew Bulletin 7(2): 149–165.

Keay, R.W.J., 1954a. Aristolochiaceae. In: Keay, R.W.J. (Editor). Flora of West Tropical Africa. Volume 1, part 1. 2nd Edition. Crown Agents for Oversea Governments and Administrations, London, United Kingdom. pp. 77–81.

Keay, R.W.J., 1954b. Combretaceae. In: Keay, R.W.J. (Editor). Flora of West Tropical Africa. Volume 1, part 1. 2nd Edition. Crown Agents for Oversea Governments and Administrations, London, United Kingdom. pp. 264–281.

Keay, R.W.J., 1954c. Cucurbitaceae. In: Keay, R.W.J. (Editor). Flora of West Tropical Africa. Volume 1, part 1. 2nd Edition. Crown Agents for Oversea Governments and Administrations, London, United Kingdom. pp. 204–216.

Keay, R.W.J., 1954d. Dioncophyllaceae. In: Keay, R.W.J. (Editor). Flora of West Tropical Africa. Volume 1, part 1. 2nd Edition. Crown Agents for Oversea Governments and Administrations, London, United Kingdom. pp. 191–194.

Keay, R.W.J., 1954e. Ochnaceae. In: Keay, R.W.J. (Editor). Flora of West Tropical Africa. Volume 1, part 1. 2nd Edition. Crown Agents for Oversea Governments and Administrations, London, United Kingdom. pp. 221–232.

Keay, R.W.J., 1956. New taxa and combinations for the 'Flora of West Tropical Africa": II. (Sapindaceae, Anacardiaceae). Bulletin du Jardin botanique de l'Etat (Bruxelles) 26(2) : 193–209.

Keay, R.W.J., 1958a. Bombacaceae. In: Keay, R.W.J. (Editor). Flora of West Tropical Africa. Volume 1, part 2. 2nd Edition. Crown Agents for Oversea Governments and Administrations, London, United Kingdom. pp. 332–335.

Keay, R.W.J., 1958b. Euphorbiaceae. In: Keay, R.W.J. (Editor). Flora of West Tropical Africa. Volume 1, part 2. 2nd Edition. Crown Agents for Oversea Governments and Administrations, London, United Kingdom. pp. 364–423.

Keay, R.W.J., 1958c. Icacinaceae. In: Keay, R.W.J. (Editor). Flora of West Tropical Africa. Volume 1, part 2. 2nd Edition. Crown Agents for Oversea Governments and Administrations, London, United Kingdom. pp. 636–644.

Keay, R.W.J., 1958d. Malvaceae. In: Keay, R.W.J. (Editor). Flora of West Tropical Africa. Volume 1, part 2. 2nd Edition. Crown Agents for Oversea Governments and Administrations, London, United Kingdom. pp. 335–350.

Keay, R.W.J., 1958e. Medusandraceae. In: Keay, R.W.J. (Editor). Flora of West Tropical Africa. Volume 1, part 2. 2nd Edition. Crown Agents for Oversea Governments and Administrations, London, United Kingdom. pp. 652–656.

Keay, R.W.J., 1958f. Moraceae. In: Keay, R.W.J. (Editor). Flora of West Tropical Africa. Volume 1, part 2. 2nd Edition. Crown Agents for Oversea Governments and Administrations, London, United Kingdom. pp. 593–616.

Keay, R.W.J., 1958g. Sapindaceae. In: Keay, R.W.J. (Editor). Flora of West Tropical Africa. Volume 1, part 2. 2nd Edition. Crown Agents for Oversea Governments and Administrations, London, United Kingdom. pp. 709–725.

Keay, R.W.J., 1958h. Tiliaceae. In: Keay, R.W.J. (Editor). Flora of West Tropical Africa. Volume 1, part 2. 2nd Edition. Crown Agents for Oversea Governments and Administrations, London, United Kingdom. pp. 300–310.

Keay, R.W.J., 1958i. Urticaceae. In: Keay, R.W.J. (Editor). Flora of West Tropical Africa. Volume 1, part 2. 2nd Edition. Crown Agents for Oversea Governments and Administrations, London, United Kingdom. pp. 616–623.

Keay, R.W.J. & Blakelock, R.A., 1958. Celastraceae. In: Keay, R.W.J. (Editor). Flora of West Tropical Africa. Volume 1, part 2. 2nd Edition. Crown Agents for Oversea Governments and Administrations, London, United Kingdom. pp. 623–634.

Keay, R.W.J. & Miège, J., 1955. Neostachyanthus occidentalis Keay et Miège: nouvelle espèce d'Icacinacée d'Afrique Occidentale. Bulletin du Jardin botanique de l'Etat (Bruxelles) 25(4): 271–279.

Keay, R.W.J. & Troupin, G., 1954. Menispermaceae. In: Keay, R.W.J. (Editor). Flora of West Tropical Africa. Volume 1, part 1. 2nd Edition. Crown Agents for Overseas Governments and Administrations, London, United Kingdom. pp. 66–77.

Keay, R.W.J., Hoyle, A.C. & Duvigneaud, P., 1958. Caesalpiniaceae. In: Keay, R.W.J. (Editor). Flora of West Tropical Africa. Volume 1, part 2. 2nd Edition. Crown Agents for Oversea Governments and Administrations, London, United Kingdom. pp. 439–484.

Keay, R.W.J., Onochie, C.F.A. & Stanfield, D.P., 1964. Nigerian trees. Volume 2. Department of Forest Research, Ibadan, Nigeria. 495 pp.

Kelly, L.M. & González, F., 2003. Phylogenetic relationships in Aristolochiaceae. Systematic Botany 28(2): 236–249.

Kemei, J.K., Wataaru, R.K. & Seme, E.N., 1997. The role of the National Genebank of Kenya in the collecting, characterization and conservation of traditional vegetables. In: Guarino, L. (Editor). Traditional African vegetables. Proceedings of the IPGRI international workshop on genetic resources of traditional vegetables in Africa: conservation and use, 29–31 August 1995, ICRAF, Nairobi, Kenya. Promoting the conservation and use of underutilized and neglected crops 16. pp. 78–85.

Kennedy, H., undated. Marantaceae. [Internet] Flora of North America. <http://www.efloras.org/florataxon.aspx?flora_id=1&taxon_id=10535>. Accessed 08 July 2010.

Keraudren, M., 1967. Cucurbitacées (Cucurbitaceae). Flore du Cameroun. Volume 6. Muséum National d'Histoire Naturelle, Paris, France. 192 pp.

Kerharo, J. & Adam, J.G., 1964. Les plantes médicinales, toxiques et magiques des Niominka et des Socé des Iles du Saloum (Sénégal). In: Haerdi, F., Kerharo, J. & Adam, J.G. (Editors). Afrikanische Heilpflanzen / Plantes médicinales africaines. Acta Tropica Supplementum 8: 279–334.

Kerharo, J. & Adam, J.G., 1974. La pharmacopée sénégalaise traditionnelle. Plantes médicinales et toxiques. Vigot & Frères, Paris, France. 1011 pp.

Kerharo, J. & Bouquet, A., 1950. Plantes médicinales et toxiques de la Côte d'Ivoire - Haute-Volta. Vigot Frères, Paris, France. 291 pp.

Keriko, J.M., Nakajima, S., Baba, N., Isozaki, Y., Ikeda, K., Alam, M.K. & Iwasa, J., 1995a. Hydroperoxides of unsaturated fatty acid methyl esters from Kenyan plant, Vernonia auriculifera. Journal of the Japan Oil Chemists' Society - Yukagaku 44(4): 338–340.

Keriko, J.M., Nakajima, S., Baba, N., Isozaki, Y., Ikeda, K., Iwasa, J. & Karanja, P.N., 1995b. A plant growth regulator from Vernonia auriculifera (Asteraceae). Zeitschrift fuer Naturforschung - Section C, Biosciences 50 (5–6): 455–458.

Kerkhoven, G.J. & Mutsaers, H.J.W., 2003. Gossypium L. In: Brink, M. & Escobin, R.P. (Editors). Plant Resources of South-East Asia No 17. Fibre plants. Backhuys Publishers, Leiden, Netherlands. pp. 139–150.

Kern, J.H., 1974. Cyperaceae. In: van Steenis, C.G.G.J. (Editor). Flora Malesiana. Series 1, Vol. 7(3). Noordhoff International Publishing, Leiden, the Netherlands. pp. 435–753.

Kerner von Marilaun, A., 1887. Pflanzenleben. Volume 1. Bibliographisches Institut, Leipzig, Germany & Vienna, Germany. 734 pp.

Keswani, C.L. & Mwenkalley, A.H., 1982. Korogwe leaf spot of sisal. FAO Plant Protection Bulletin 30: 145–150.

Keya, N.C.O., 1973. The effect of NP fertilizers on the productivity of Hyparrhenia grassland. East African Agricultural and Forestry Journal 39(2): 195–200.

Keya, N.C.O. & Kalangi, D.W., 1973. The seeding and superphosphate rates for the establishment of Desmodium uncinatum (Jacq.) DC. by oversowing in uncultivated grasslands of Western Kenya. Tropical Grasslands 7(3): 319–325.

Kgathi, D.L., Mmopelwa, G. & Mosepele, K., 2005. Natural resources assessment in the Okavango Delta, Botswana: case studies of some key resources. Natural Resources Forum 29: 70–81.

Khafaga, E.R., 1983. Vegetative propagation of cotton (Gossypium L. spp.). I. Rooting ability of cuttings. Angewandte Botanik 57: 227–235.

Khajuria, A., Gupta, A., Garai, S. & Wakhloo, B.P., 2007. Immunomodulatory effects of two sapogenins 1 and 2 isolated from Luffa cylindrica in Balb/C mice. Bioorganic and Medicinal ChemistryLetters 17(6): 1608–1612.

Khalumba, M.L., Mbugua, P.K. & Kung'u, J.B., 2005. Uses and conservation of some highland species of the genus Sansevieria Thunb. in Kenya. African Crop Science Conference Proceedings 7: 527–532.

Khan, M.R., 2001. Antibacterial activity of some Tanzanian medicinal plants. Pharmaceutical Biology 39(3): 206–212.

Khan, M.N., Ngasappa, O. & Matee, M.I.N., 2000. Antimicrobial activity of Tanzanian chewing sticks against oral pathogen microbes. Pharmaceutical Biology 38: 235–240.

Khan, T., Ahmad, W., Bashir, S., Iqbal, Z., Ahmad, B., Ahmad, M., Nisarullah, Arfan, M. & Shaheen, F., 2003. Biological and pharmacological properties of Abroma augusta Linn. seed oil. Pakistan Journal of Biological Sciences 6(13): 1142–1144.

Khandakar, A.L. & van der Vossen, H.A.M., 2003. Corchorus L. In: Brink, M. & Escobin, R.P. (Editors). Plant Resources of South-East Asia No 17. Fibre plants. Backhuys Publishers, Leiden, Netherlands. pp. 106–114.

Khristova, P., Kordsachia, O. & Khider, T., 2003. Pulping potential of doum palm rachis from Sudan. Tropical Science 43(3): 109–115.

Kiambi, D., 1999. Assessment of the status of agrobiodiversity in Djibouti: a contribution to the National Biodiversity Strategy and Action Plan. Draft report. IPGRI, Nairobi, Kenya. 61 pp.

Kimani, P. & Obura, D., 2004. Participatory mapping of terrestrial fishery resources in Kwale District, Kenya. Western Indian Ocean Journal of Marine Science 3(2): 209–220.

Kimaro, D.N., 1994. Review of sisal production and research in Tanzania. African Study Monographs 15(4): 227–242.

Kimenju, J.W., Kagundu, A.M., Nderitu, J.H., Omuolo, F.M. & Mutua, G. K., 2007. Use of green manure plants in cropping systems to suppress root-knot nematodes. In: Proceedings of the 8th African Crop Science Society Conference, El-Minia, Egypt, 27–31 October 2007. pp. 1083–1085.

Kindomihou, V., Sinsin, B. & Meerts, P., 2006. Effect of defoliation on silica accumulation in five tropical fodder grass species in Benin. Belgian Journal of Botany 139(1): 87–102.

Kinnaird, M.F., 1992. Competition for a forest palm: use of Phoenix reclinata by human and non-human primates. Conservation Biology 6(1): 101–107.

Kipkemboi, J., van Dam, A.A. & Denny, P., 2006. Biophysical suitability of smallholder integrated aquaculture-agriculture systems (fingerponds) in East Africa's Lake Victoria freshwater wetlands. International Journal of Ecology and Environmental Sciences 32(1): 75–83.

Kirby, R.H., 1948. Abroma augusta fibre from Uganda. Bulletin of the Imperial Institute 46: 192–197.

Kirby, R.H., 1950. Brush-making fibres. Economic Botany 4(3): 243–252.

Kirby, R.H., 1963. Vegetable fibres: botany, cultivation, and utilization. Leonard Hill, London, United Kingdom & Interscience Publishers, New York, United States. 464 pp.

Kirk, J.H. & Higginbotham, G.E., 1999. Pima cotton, gossypol and dairy cattle: is it a bad combination? The Western Dairyman 80(8): 32–33.

Kirkpatrick, T.L. & Rothrock, C.S., 2001. Compendium of cotton diseases. 2nd Edition. APS (American Phytopathological Society) Press, St. Paul, Minnesota, United States. 77 pp.

Kirtikar, K.R. & Basu, B.D., 1918. Indian Medicinal Plants. Sudhindra Nath, Basu, Bahadar Ganj Allahabad.

Kisangau, D.P., Lyaruu, H.V.M., Hosea, K.M. & Joseph, C.C., 2007. Use of traditional medicines in the management of HIV/AIDS opportunistic infections in Tanzania: a case in the Bukoba rural district. Journal of Ethnobiology and Ethnomedicine 3: 29.

Kittur, M.H., Mahajanshetti, C.S., Rao, K.V.S.A. & Lakshminarayana, G., 1982. Characteristics and composition of Abutilon pannosum and Hibiscus panduriformis seeds and oils. Journal of the American Oil Chemists' Society 59(3): 123–124.

Klaassen, E.S. & Craven, P., 2003. Checklist of grasses in Namibia. Southern African Botanical Diversity Network Report No 20. SABONET, Pretoria, South Africa. 130 pp.

Knecht, M., 1983. Aracées de la Côte d'Ivoire - Contribution à l'étude biosystématique des représentants d'Aracées de la Côte d'Ivoire. Phanerogamarum Monographiae 17. 290 pp.

Koechlin, J., 1962. Graminées. Flore du Gabon. Volume 5. Muséum National d'Histoire Naturelle, Paris, France. 292 pp.

Koechlin, J., 1964. Marantacées. Flore du Gabon. Volume 9. Muséum National d'Histoire Naturelle, Paris, France. pp. 91–158.

Koechlin, J., 1965. Marantaceae. Flore du Cameroun. Volume 4. Muséum National d'Histoire Naturelle, Paris, France. pp. 99–157.

Kokou, K., Batawila, K., Akoegninou, A. & Akpagana, K., 2000. Analyse morpho-structurale et diversité floristique des îlots de forêt protegés dan la plaine côtiere du sud du Togo. Etudes de la flore et la végétation de Burkina Faso 5: 33–48.

Kokwaro, J.O., 1986. Anacardiaceae. In: Polhill, R.M. (Editor), 1986. Flora of Tropical East Africa. A.A. Balkema, Rotterdam, Netherlands. 59 pp.

Kokwaro, J.O., 1993. Medicinal plants of East Africa. 2nd Edition. Kenya Literature Bureau, Nairobi, Kenya. 401 pp.

Koné, M.W. & Kamanzi, A.K., 2006. Inventaire ethnomédical et évaluation de l'activité anthelminthique des plantes médicinales utilisées en Côte d'Ivoire contre les helminthiases intestinales. Pharm. Méd. Trad. Afr. 14: 55–72.

Koni Muluwa, J. & Bostoen, K., 2008a. Les plantes et l'invisible chez les Mbuun, Mpiin et Nsong (Bandundu, RD Congo) : une approche ethnolinguistique. Sprache und Geschichte in Afrika 21: 95–122.

Koni Muluwa, J. & Bostoen, K., 2008b. Noms et usages des plantes utiles chez les Nsong (RD Congo, Bandundu, bantu B85F). Göteborg Africana Informal Series No 6. Department of Oriental and African Languages, University of Gothenburg, Sweden. 65 pp.

Koopman, M.M., 2011. A synopsis of the Malagasy endemic genus Megistostegium Hochr. (Hibisceae, Malvaceae). Adansonia, séries 3, 33 (1): 101–113.

Koshimizu, K., Ohigashi, H., Huffman, M.A., Nishida, T. & Takasaki, H., 1993. Physiological activities and the active constituents of potentially medicinal plants used by wild chimpanzees of the Mahale Mountains, Tanzania. International Journal of Primatology 14(2): 345–356.

Kotschy, K. & Rogers, K., 2008. Reed clonal characteristics and response to disturbance in a semiarid river. Aquatic Botany 88: 47–56.

Kouakou, K.L., Zoro Bi, I.A., Abessika, Y.G., Kouakou, T.H. & Baudoin, J.-P., 2009a. Rapid seedlings regeneration from seeds and vegetative propagation with sucker and rhizome of Eremospatha macrocarpa (Mann & Wendl.) and Laccosperma secundiflorum (P.Beauv.) Kuntze. Scientia Horticulturae 120: 257–263.

Kouakou, K.L., Zoro Bi, I.A., Kouakou, T.H., Koné, M. & Baudoin, J.-P., 2009b. Direct regeneration of rattan seedlings from apical meristem and axillary bud explants. Belgian Journal of Botany 142(1): 60–67.

Kouassi, K.I., Barot, S., Gignoux, J. & Zoro Bi, I.A., 2008. Demography and life history of two rattan species, Eremospatha macrocarpa and Laccosperma secundiflorum, in Cote d'Ivoire. Journal of Tropical Ecology 24: 493–503.

Kozlowski, R., Rawluk, M. & Barriga-Bedoya, J., 2005. Ramie. In: Franck, R.R. (Editor). Bast and other plant fibres. Woodhead Publishing, Cambridge, United Kingdom & CRC Press, Boca Raton, Florida, United States. pp. 207–227.

Kremen, C., Raymond, I., Lance, K. & Weiss, A., 1996. Monitoring natural resource use on the Masoala Peninsula, Madagascar: a tool for managing integrated conservation and development projects. In: Saterson, K., Margoluis, R. & Salafsky, N. (Editors). Measuring conservation impact: an interdisciplinary approach to project monitoring and evaluation. Proceedings from a Biodiversity Support Program symposium held at the joint annual meetings of the Ecological Society of America and the Society for Conservation Biology in Providence, Rhode Island, August 1996. World Wildlife Fund, Washington D.C., United States. pp. 63–82.

Kristensen, M. & Lykke, A.M., 2003. Informant-based valuation of use and conservation preferences of savanna trees in Burkina Faso. Economic Botany 57(2): 203–217.

Krog, M., Falcão, M.P. & Smith Olsen, C., 2006. Medicinal plant markets and trade in Maputo, Mozambique. Working Papers No 16–2006 Development & Environment. Danish Centre for Forest, Landscape and Planning, KVL, Hørsholm, Denmark. 39 pp.

Kryn, J.M. & Fobes, E.W., 1959. The woods of Liberia. Report 2159. USDA Forest Service, Forest Products Laboratory, Madison, Wisconsin, United States. 147 pp.

Ku Mbuta, K., Mwima, K., Bitengeli, M., Y'okolo, I., Kavuna, M., Mandanga, M., Kalambayi, M., Izamajole, N., Kazembe, K., Booto, K., Vasaki, N., Mwabonsika, B. & Lody, D., 2008. Recueil des plantes utilisées en médecine traditionnelle Congolaise. Vol.1. Province de l'Equateur. Institut de Recherche en Sciences de la Santé. 404 pp.

Kubitzki, K. & Bayer, C., 2003. Families and genera of vascular plants. Vol. 5. Flowering plants, dicotyledons : Malvales, Capparales and non-betalain Caryophyllales. Springer, Berlin, Germany. 418 pp.

Kulkarni, V.N., Khadi, B.M., Maralappanavar, M.S., Deshapande, L.A. & Narayanan, S.S., 2009. The worldwide gene pools of Gossypium arboreum L. and G. herbaceum L., and their improvement. In: Paterson, A.H. (Editor). Genetics and genomics of cotton. Springer-Verlag New York, United States. pp. 69–97.

Kumar, S., Kumar, D. & Rakash, O., 2008. Evaluation of antioxidant potential, phenolic and flavonoid contents of Hibiscus tiliaceus flowers. Electronic Journal of Environmental, Agricultural and Food Chemistry 7(4): 2863–2871.

Kumar, D., Kumar, S., Kumar, S., Singh, J., Sharma, C. & Aneja, K.R., 2010. Antimicrobial and preliminary phytochemical screening of crude leaf extract of Pandanus odoratissimus L. [Internet] Pharmacologyonline 2: 600–610. <http://www.unisa.it/ download/ 1966_11225_1830772171_58.Kumar.pdf>. Accessed March 2011.

Kunnumakkara, A.B., Nair, A.S., Ahn, K.S., Pandey, M.K., Yi, Z., Liu, M. & Aggarwal, B.B., 2007. Gossypin, a pentahydroxyl glucosyl flavone, inhibits the transforming growth factor beta-activated kinase-1-mediated NF-kB activation pathway, leading to potentiation of apoptosis, suppression of invasion, and abrogation of osteoclastogenesis. Blood 109(12): 5112–5121.

Kupchan, S.M., Sweeney, J.G., Baxter, R.L., Murae, T., Zimmerly, V.A. & Sickles, B.R., 1975. Gnididin, gniditrin, and gnidicin, novel potent antileukemic diterpenoid esters from Gnidia lamprantha. Journal of the American Chemical Society 97(3): 672–673.

Kupchan, S.M., Shizuri, Y., Murae, T., Sweeny, J.G., Haynes, H.R., Shen, M.-S., Barrick, J.C. & Bryan, R.F., 1976a. Gnidimacrin and gnidimacrin 20-palmitate, novel macrocyclic antileukemic diterpenoid esters from Gnidia subcordata. Journal of the American Chemical Society 98(18): 5719–5720.

Kupchan, S.M., Shizuri, Y., Sumner, W.C., Haynes, H.R., Leighton, A.P. & Sickles, B.R., 1976b. Isolation and structural elucidation of new potent antileukemic diterpenoid esters from Gnidia species. Journal of Organic Chemistry 41(24): 3850–3853.

Kupchan, S.M., Shizuri, Y., Baxter, R.L. & Haynes, H.R., 1977. Gnididione, a new furanosesquiterpene from Gnidia latifolia. Journal of Organic Chemistry 42(2): 348–350.

Kushwaha, S.P.S., Sharma, K.P. & Gopal, B., 1991. Stand structure and biomass distribution in Phragmites karka populations at Jaipur, India. International Journal of Ecology and Environmental Sciences 17: 55–65.

Kuzee, M.E. & Bongers, F., 2005. Climber abundance, diversity and colonisation in degraded forests of different ages in Côte d'Ivoire. In: Bongers, F., Parren, M.P.E. & Traoré, D. (Editors). Forest climbing plants of West Africa. Diversity, ecology and management. CABI Publishing, Wallingford, United Kingdom. pp. 73–91.

Kyei, B.K., 2004. Chemical analysis of three Ghanaian rattan species (Calamus deeratus, Eremospatha macrocarpa and Laccosperma secundiflorum). B.Sc. Natural Resource Management degree thesis, Institute of Renewable Natural Resources, Kwame Nkrumah University of Science and Technology, Kumasi, Ghana. 42 pp.

Laclau, J.-P., Bouillet, J.-P. & Ranger, J., 2000. Dynamics of biomass and nutrient accumulation in a clonal plantation of Eucalyptus in Congo. Forest Ecology and Management 128(3): 181–196.

Lagnika, L., Attioua, B., Weniger, B., Kaiser, M., Sanni, A. & Vonthron-Senecheau, C., 2008. Phytochemical study and antiprotozoal activity of compounds isolated from Thalia geniculata. Pharmaceutical Biology 46(3): 162–165.

Laivao, M.O., 2008. Contribution à la systématiques du genre Pandanus (Pandanaceae) à Madagascar. Thèse de Doctorat es Sciences, Faculté des Sciences, Institut de Biologie, Laboratoire de Botanique Evolutive, Université de Neuchâtel, Neuchâtel, Suisse. 284 pp.

Laivao, M.O., Callmander, M.W. & Buerki, S., 2007. Révision de Pandanus sect. Foullioya Warb. (Pandanaceae) à Madagascar. Adansonia 29 (1): 39–57.

Lakshminarayana, A., Murty, R.K., Rao, M.R. & Rao, P.A., 1980. Efficiency of nitrogen utilization by roselle and kenaf (Hibiscus sabdariffa, Hibiscus cannabinus). Indian Journal of Agricultural Science 50: 244–248.

Lamb, D., Johns, R.J., Keating, W.G., Ilic, J. & Jongkind, C.C.H., 1993. Eucalyptus L'Hér. In: Soerianegara, I. & Lemmens, R.H.M.J. (Editors). Plant Resources of South-East Asia No 5(1). Timber trees: Major commercial timbers. Pudoc Scientific Publishers, Wageningen, Netherlands. pp. 200–211.

Lambertini, C., Gustafsson, M.H.G., Frydenberg, J., Lissner, J., Speranza, M. & Brix, H., 2006. A phylogeographic study of the cosmopolitan genus Phragmites (Poaceae) based on AFLPs. Plant Systematics and Evolution 258(3–4): 161–182.

Lambertini, C., Gustafsson, M.H.G., Frydenberg, J., Speranza, M. & Brix, H., 2008. Genetic diversity patterns in Phragmites australis at the population, regional and continental scales. Aquatic Botany 88(2): 160–170.

Lamprecht, H., 1989. Silviculture in the tropics: tropical forest ecosystems and their tree species, possibilities and methods for their long-term utilization. Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ) GmbH, Eschborn, Germany. 296 pp.

Lantz, H., Andreasen, K. & Bremer, B., 2002. Nuclear rDNA ITS sequence data used to construct the first phylogeny of Vanguerieae (Rubiaceae). Plant Systematics and Evolution 230(3–4): 173–187.

Larbi, A., Smith, J.W., Kurdi, I.O., Adekunle, I.O., Raji, A.M. & Ladipo, D.O., 1998. Chemical composition, rumen degradation, and gas production characteristics of some multipurpose fodder trees and shrubs during wet and dry seasons in the humid tropics. Animal Feed Science and Technology 72(1–2): 81–96.

Latham, P., 2004. Useful plants of Bas-Congo province, Democratic Republic of the Congo. DFID, London, United Kingdom. 320 pp.

Latham, P., 2005. Some honeybee plants of Bas-Congo Province, Democratic Republic of Congo. DFID, United Kingdom. 167 pp.

Latham, P., 2007. Plants visited by bees and other useful plants of Umalila, southern Tanzania. Third edition. P.Latham, DFID, United Kingdom. 216 pp.

Launert, E., 1971. Gramineae (Bambuseae - Pappophoreae). In: Fernandes, A., Launert, E. & Wild, H. (Editors). Flora Zambesiaca. Volume 10, part 1. Flora Zambesiaca Managing Committee, London, United Kingdom. 152 pp.

Lauzer, D., Dallaire, S. & Vincent, G., 2000. In vitro propagation of reed grass by somatic embryogenesis. Plant Cell, Tissue and Organ Culture 60: 229–234.

Law, V. & Jarman, C.G., 1962. Doum palm leaflet fibre. Tropical Science 4: 123–126.

Lawani, A., 2007. Contribution du bois energie aux moyens d'existence durables des ménages riverains de la Réserve de biosphère de la Pendjari. Thèse ingénieur agronome, Faculté des Sciences Agronomiques, Université d'Abomey Calavi, Bénin. 133 pp.

Lawton, R.M., 1968. The value of browse in the dry tropics. East African Agricultural and Forestry Journal 33(3): 227–230.

Lawton, R.M., 1980. Browse in miombo woodland. In: Le Houérou, H.N. (Editor). Browse in Africa: the current state of knowledge. International Livestock Centre for Africa, Addis Ababa, Ethiopia. pp. 25–31.

Lay, C.L. & Dybing, C.D., 1989. Linseed. In: Röbbelen, G., Downey, R. & Ashri, A. (Editors). Oil crops of the world, McGraw-Hill, New York, United States. pp. 416–430.

le Floc'h, E., Lemordant, D., Lignon, A. & Rezkallah, N., 1985. Pratiques ethnobotaniques des populations Afars de la moyenne vallée de l'Awash (Ethiopie). Journal of Ethnopharmacology 14: 283–314.

Le Houérou, H.N., 1973. Contribution à une bibliographie des phénomènes de désertisation, de l'écologie végétale des pâturages et du nomadisme dans les régions arides de l'Afrique et de l'Asie du Sud-Ouest. FAO, Division de la Production végétale et de la protection des plantes, Rome, Italy. 120 pp.

Le Houérou, H.N., 1980. The role of browse in the Sahelian and Sudanian zones. [Internet] In: Le Houérou, H.N. (Editor). Browse in Africa: The current state of knowledge. Papers presented at the International Symposium on Browse in Africa, Addis Ababa, Ethiopia, April 8–12, 1980. International Livestock Center for Africa, Addis Ababa, Ethiopia. 491 pp. <http://www.ilri.org/ InfoServ/Webpub/fulldocs/ BROWSE_IN_AFRICA/toc.htm#TopOfPage>. Accessed May 2011.

Le Houérou, H.N., 1989. The grazing land ecosystems of the African Sahel. Ecological studies 75. Springer-Verlag, Berlin, Germany. 282 p.

Le Houérou, H.N. (Editor), 1980. Browse in Africa: the current state of knowledge. Papers presented at the International Symposium on Browse in Africa, Addis Ababa, April 8–12, 1980, and other submissions. International Livestock Centre for Africa, Addis Ababa, Ethiopia. 491 pp.

Leakey, R.R.B., Mesén, J.F., Tchoundjeu, Z., Longman, K.A., Dick, J.M., Newton, A., Matin, A., Grace, J., Munro, R.C. & Muthoka, P.N., 1990. Low-technology techniques for the vegetative propagation of tropical trees. Commonwealth Forestry Review 69(3): 247–257.

Lean Teik Ng & Su Foong Yap, 2003. Pandanus Parkinson. In: Lemmens, R.H.M.J. & Bunyapraphatsara, N. (Editors). Plant Resources of South-East Asia No 12(3). Medicinal and poisonous plants 3. Backhuys Publishers, Leiden, Netherlands. pp. 321–323.

Leandri, J., 1950. Thyméléacées (Thymelaeaceae). Flore de Madagascar et des Comores (plantes vasculaires), famille 146. Firmin-Didot et cie., Paris, France. 40 pp.

Leandri, J., 1965. Urticacées (Urticaceae). Flore de Madagascar et des Comores (plantes vasculaires), famille 56. Muséum National d'Histoire Naturelle, Paris, France. 107 pp.

Lebot, V. & Ranaivoson, L., 1994. Eucalyptus genetic improvement in Madagascar. Forest Ecology and Management 63(2–3): 135–152.

Lebrun, J.P. & Stork, A.L., 2010. Tropical flowering plants; ecology and distribution. Volume 5: Buxaceae-Simaroubaceae. Editions des Conservatoire et Jardin botaniques de la ville de Genève, Switzerland. 415 pp.

Lee, D., Bhat, K.P.L., Fong, H.H.S., Farnsworth, N.R., Pezzuto, J.M. & Kinghorn, A.D., 2001. Aromatase inhibitors from Broussonetia papyrifera. Journal of Natural Products 64(10): 1286–1293.

Leenders, J.K., 2006. Wind erosion control with scattered vegetation in the Sahelian zone of Burkina Faso. Tropical Resource Management Papers No 73. Wageningen University and Research Centre, Wageningen, Netherlands. 170 pp.

Leeson, S. & Caston, L.J., 2004. Feeding value of dehulled flaxseed. Canadian Journal of Animal Science 84: 545–547.

Leeuwenberg, A.J.M., 1969. The Loganiaceae of Africa 8. Strychnos 3. Revision of the African species with notes on the extra-African. Mededelingen Landbouwhogeschool Wageningen 69–1. Wageningen, Netherlands. 316 pp.

Leeuwenberg, A.J.M., 1972. Loganiaceae. Flore du Cameroun. Volume 12. Muséum National d'Histoire Naturelle, Paris, France. 153 pp.

Leeuwenberg, A.J.M., 1997. Series of revisions of Apocynaceae 43. Alafia Thouars. Kew Bulletin 52(4): 769–839.

Leeuwenberg, A.J.M. & Bamps, P., 1979. Loganiaceae. In: Bamps, P. (Editor). Flore d'Afrique centrale. Spermatophytes. Jardin botanique national de Belgique, Brussels, Belgium. 149 pp.

Leger, S., 1997. The hidden gifts of nature: A description of today's use of plants in West Bushmanland (Namibia). [Internet] DED, German Development Service, Windhoek, Namibia & Berlin, Germany. <http://www.sigridleger.de/book/>. Accessed February 2011.

Leigh, J.H., 1961. Persistence of some varieties of pasture grass and their susceptibility to invasion by other species. Journal of Ecology 49(2): 341–345.

Leistner, O.A., 2005. Seed plants of southern tropical Africa: families and genera. Southern African Botanical Diversity Network, Report No. 26. SABONET, Pretoria, South Africa. 498 pp.

Leithead, H.L., Yarlett, L.L. & Shiflett, T.N., 1976. 100 native forage grasses in 11 southern states. [Internet] Agriculture Handbook No 389. Soil Conservation Service, U.S. Department of Agriculture, Washington DC, United States. <http://npdc.usda.gov/ pdf/100_native_grasses.pdf>. Accessed March 2011.

Lejeune, J.B.H., 1953. Contribution à l'étude des plantes à fibres, à Rubona. Bulletin Agricole du Congo Belge 44: 743–772.

Lejoly, J. & Lisowski, S., 1984. Le genre Neuropeltis Wall. (Convolvulaceae) au Zaïre, au Gabon et au Cameroun. Bulletin du Jardin Botanique National de Belgique 54: 471–482.

Lens, F., Jansen, S., Huysmans, S., Robbrecht, E. & Smets, E., 2000a. Pollen morphological variation in Vanguerieae (Ixoroideae - Rubiaceae). Grana 39: 90–102.

Lens, F., Jansen, S., Robbrecht, E. & Smets, E., 2000b. Wood anatomy of the Vanguerieae (Ixoroideae–Rubiaceae), with special emphasis on some geofrutices. IAWA Journal 21(4): 443–455.

León, H., 1946. Flora de Cuba. Vol. 1. Gimnospermas – Monocotiledoneas. Contribuciones ocasionales del Museo de Historia Natural No. 8. Cultural S. A. , Havana, Cuba. 441 pp.

Léonard, J., 1962. Euphorbiaceae. In: Robyns, W., Staner, P., Demaret, F., Germain, R., Gilbert, G., Hauman, L., Homès, M., Jurion, F., Lebrun, J., Vanden Abeele, M. & Boutique, R. (Editors). Flore du Congo belge et du Ruanda-Urundi. Spermatophytes. Volume 8, 1. Institut National pour l'Étude Agronomique du Congo belge, Brussels, Belgium. 214 pp.

Léonard, J. & Voorhoeve, A.G., 1964. Notulae Systematicae 35. The genera Stachyothyrsus Harms and Kaoue Pellegr. (African Caesalpiniaceae). Bulletin du Jardin Botanique de l'Etat (Bruxelles) 34(3): 419–423.

Letouzey, R., 1968. Urticaceae. Flore du Cameroun. Volume 8. Muséum National d'Histoire Naturelle, Paris, France. pp. 67–216.

Letouzey, R., 1978. Notes phytogéographiques sur les palmiers du Cameroun. Adansonia 18(3): 293–325.

Letouzey, R., 1982a. Manual of forest botany. Tropical Africa. Vol. 2A. Centre Technique Forestier Tropical, Nogent-sur-Marne, France. pp. 152–163.

Letouzey, R., 1982b. Manuel de botanique forestière - Afrique tropicale. Tome 2A: Familles (première partie). Centre Technique Forestier Tropical, Nogent sur Marne, France. 210 pp.

Leung, W.-T.W., Busson, F. & Jardin, C., 1968. Food composition table for use in Africa. FAO, Rome, Italy. 306 pp.

Lewin, M., 2007. Handbook of fiber chemistry. 3rd Edition. CRC Press, Boca Raton, Florida, United States. 1052 pp.

Lewis, G.P. & Guinet, P., 1986. Notes on Gagnebina (Leguminosae - Mimosoideae) in Madagascar and neighbouring islands. Kew Bulletin 41(2): 463–470.

Lewis, G., Schrire, B., MacKinder, B. & Lock, M., 2005. Legumes of the world. Royal Botanic Gardens, Kew, Richmond, United Kingdom. 577 pp.

Ley, A.C., 2008. Evolutionary tendencies in African Marantaceae - evidence from floral morphology, ecology and phylogeny. PhD thesis, Johannes Gutenberg Universität, Mainz, Germany. 187 pp.

Ley, A.C. & Claβen-Bockhoff, R., 2009. Pollination syndromes in African Marantaceae. Annals of Botany 104: 41–56.

Leyens, T. & Lobin, W., 2009. Manual de plantas úteis de Angola. Bischöfliches Hilfswerk Misereor, Aachen, Germany. 181 pp.

Li, X.C., van der Bijl, P. & Wu, C.D., 1998. Binaphthalenone glycosides from African chewing sticks, Diospyros lycioides. Journal of Natural Products 61(6): 817–820.

Liben, L., 1983. Combretaceae. Flore du Cameroun. Volume 25. Muséum National d'Histoire Naturelle, Paris, France. 97 pp.

Liengola, I.B., 2001. Contribution à l'étude des plantes alimentaires spontanées chez les Turumbu et Lokele du District de la Tshopo, Province Orientale, R.D. Congo. Systematics and Geography of Plants 71(2): 687–698.

Lim, T.T. & Huang, X., 2007. Evaluation of kapok (Ceiba pentandra (L.) Gaertn.) as a natural hollow hydrophobic-oleophilic fibrous sorbent for oil spill cleanup. Chemosphere 66(5): 955–963.

Lin, C.-C., Yen, M.-H., Lo, T.-S. & Lin, C.-F., 1997. The antiinflammatory and liver protective effects of Boehmeria nivea and B. nivea subsp. nippononivea in rats. Phytomedicine 4(4): 301–308.

Lin, C.-C., Yen, M.-H., Lo, T.-S. & Lin, J.-M., 1998. Evaluation of the hepatoprotective and antioxidant activity of Boehmeria nivea var. nivea and B. nivea var. tenacissima. Journal of Ethnopharmacology 60: 9–17.

Lind, E.M. & Tallantire, A.C., 1975. Some common flowering plants of Uganda. 2nd Edition. Oxford University Press, Nairobi, Kenya. 257 pp.

Lisowski, S., 2009. Flore (Angiospermes) de la République de Guinée: première partie. Scripta Botanica Belgica. Volume 41. Jardin Botanique National de Belgique, Belgium. 517 pp.

Lisowski, S., Malaisse, F. & Symoens, J.J., 1973. Juncaceae. In: Bamps, P. (Editor). Flore d'Afrique centrale. Spermatophytes. Jardin botanique national de Belgique, Brussels, Belgium. 13 pp.

Lisson, S.N., 2003. Linum usitatissimum L. In: Brink, M. & Escobin, R.P. (Editors). Plant Resources of South East Asia No 17. Fibre plants. Backhuys Publishers, Leyden, Netherlands. pp. 172–179.

Little, E.L., Woodbury, R.O. & Wadsworth, F.H., 1974. Trees of Puerto Rico and the Virgin Islands. Volume 2. Agriculture Handbook No 449. United States Department of Agriculture, Washington D.C., United States. 1024 pp.

Liu, A., 2000. Kenaf (Hibiscus cannabinus L.) research and development in the International Jute Organization (IJO). In: Proceedings of the Third Annual Conference of the American Kenaf Society, Corpus Christi, Texas, USA. 6 pp.

Liu, Y-K., Seki, M., Tanaka, H. & Furusaki, S., 1998. Characteristics of loofa (Luffa cylindrica) sponge as a carrier for plant cell immobilization. Journal of Fermentation and Bioengineering 85(4): 416–421.

Liu, K., Eastwood, R.J., Flynn, S., Turner, R.M. & Stuppy, W.H., 2008a. Commiphora multijuga. [Internet] Seed Information Database Release 7.1, May 2008. <http://data.kew.org/sid/>. Accessed August 2010.

Liu, K., Eastwood, R.J., Flynn, S., Turner, R.M. & Stuppy, W.H., 2008b. Pavonia urens. [Internet] Seed Information Database Release 7.1, May 2008. <http://data.kew.org/sid/>. Accessed January 2010.

Llamas, K.A., 2003. Tropical flowering plants: a guide to identification and cultivation. Timber Press, Portland, United States. 425 pp.

Lock, G.W., 1969. Sisal: thirty years' sisal research in Tanzania. 2nd Edition. Longmans, London, United Kingdom. 365 pp.

Lock, J.M., 1989. Legumes of Africa: a check-list. Royal Botanic Gardens, Kew, Richmond, United Kingdom. 619 pp.

Lockett, C.T. & Grivetti, L.E., 2000. Food-related behaviors during drought: a study of rural Fulani, northeastern Nigeria. International Journal of Food Sciences and Nutrition 51(2): 91 107.

Lockhart, B.E.L., 2000. Virus diseases of Musa in Africa: epidemiology, detection and control. Acta Horticulturae 540: 355–359.

Lodge, G.M., McCormick, L.H. & Harden, S., 2005. Grazing studies of a Hyparrhenia hirta (Coolatai grass) pasture in northern New South Wales. Australian Journal of Experimental Agriculture 45(12): 1603–1611.

Loesener, T., 1937. Celastraceae novae vel melius cognoscendae III. Notizblatt des botanischen Gartens und Museums zu Berlin-Dahlem 13(120): 564–581.

Loewenstein, N.J. & Miller, J.H. (Editors), 2007. Proceedings of the regional cogongrass conference: a cogongrass management guide. Confronting the cogongrass crisis across the South. Arthur R. Outlaw Convention Center, Mobile, Alabama, United States. 77 pp.

Loffler, L. & Loffler, P., 2005. Swaziland tree atlas. Southern African Botanical Diversity Network Report No 38. SABONET, Pretoria, South Africa. 188 pp.

Londonkar, R., Kamble, A. & Reddy, V.C., 2010. Anti-inflammatory activity of Pandanus odoratissimus extract. International Journal of Pharmacology 6(3): 311–314.

Lonsdale, W.M, Farrell, G. & Wilson, C.G., 1995. Biological control of a tropical weed: a population model and experiment for Sida acuta. Journal of Applied Ecology 32(2): 391–399.

Lopes, D.C. & Steidle Neto, A.J., 2011. Potential Crops for Biodiesel Production in Brazil: a review. World Journal of Agricultural Sciences 7(2): 206–217.

López, C.R., 1982. Determinación de los nematodos fitoparásitos asociados al plátano (Musa acuminata × M. balbisiana, AAB) en Río Frío. Agronomía Costarricense 4(2): 143–147.

Lorenzen, B., Brix, H., McKee, K.L., Mendelssohn, I.A. & Miao, S., 2000. Seed germination of two Everglades species, Cladium jamaicense and Typha domingensis. Aquatic Botany 66(3): 169–180.

Lorougnon, G., 1972. Les Cypéracées forestières de Côte d'Ivoire. Mémoires ORSTOM No 58. Office de la Recherche Scientifique et Technique Outre-Mer, Paris, France. 102 pp.

Lovett, J.C., undated. Notes on moist forest bamboos and bambusoid grasses in eastern Tanzania. [Internet] <http://celp.org.uk/ webpages/projects/ecology/EA%20natural%20history/pdf/ NOTES%20ON%20MOIST%20FOREST%20BAMBOOS.pdf>. Accessed May 2011.

Lovett, J. & Clarke, G.P., 1998. Julbernardia magnistipulata. In: IUCN. Red list of threatened species. Version 2010.1. [Internet] <http://www.iucnredlist.org> Accessed March 2010.

Lovett, J.C., Ruffo, C.K. & Gereau, R.E., 2003. Field guide to the moist forest trees of Tanzania. [Internet] Centre for Ecology Law and Policy, Environment Department, University of York, York, United Kingdom. 192 pp. <http://www.cepf.net/ Documents/Final_LovettRuffoGereau_FieldGuide.pdf>. Accessed April 2010.

Lovett, J.C., Ruffo, C.K., Gereau, R.E. & Taplin, J.R.D., 2006. Field guide to the moist forest trees of Tanzania. [Internet] Centre for Ecology Law and Policy, Environment Department, University of York, York, United Kingdom. <http://celp.org.uk/ projects/ tzforeco/>. Accessed February 2009 - July 2011.

Lovett, J.C., Ruffo, C.K., Gereau, R.E. & Taplin, J.R.D., 2007. Field guide to the moist forest trees of Tanzania. [Internet] Centre for Ecology Law and Policy, Environment Department, University of York, York, United Kingdom. <http://celp.org.uk/ projects/ tzforeco/>. Accessed June 2009.

Lowry, J.B., Kennedy, P.M. & Conlan, L.L., 2002. Lignin in the ‘cell contents’ fraction of tropical forages. Journal of the Science of Food and Agriculture 82: 370–374.

Lowry, P.P., Randriatafika, F. & Rabenantoandro, J., 2008. Conservation status of vascular plant species from the QMM / Rio Tinto mining area at Mandena, Tolagnaro (Fort Dauphin) region, southeast Madagascar. Madagascar Conservation & Development 3(1): 55–63.

Lubini, A., 1994. Utilisation de plantes par les Yansi del’entre Kwilu-Kasai (Zaire). In: Seyani, J.H. & Chikuni, A.C. (Editors). Proceedings of the 13th plenary meeting of AETFAT, Zomba, Malawi. Volume 1. National Herbarium and Botanic Gardens of Malawi, Zomba, Malawi. pp. 53–74.

Lubke, R.A. & Phipps, J.B., 1973. Taximetrics of Loudetia (Gramineae) based on leaf anatomy. Canadian Journal of Botany 51: 2127–2146.

Lucas, E.B. & Dahunsi, B.I.O., 2004. Characteristics of three western Nigerian rattan species in relation to their utilization as construction material. Journal of Bamboo and Rattan 3(1): 45–56.

Lucas, G. & Synge, H., 1978. The IUCN plant red data book. IUCN, Morges, Switzerland. 540 pp.

Luckow, M., 2002. Anatomical features of the leaves in the Dichrostachys group (Leguminosae: Mimosoideae) and their utility for phylogenetic studies. Systematic Botany 27(1): 29–40.

Luhs, W. & Friedt, W., 1994. The major oil crops. In: Murphy, D.J. (Editor). Designer oil crops: breeding, processing and biotechnology. VCH Press, Weinheim, Germany. pp. 5–71.

Lukonge, E., Labuschange, M.T. & Hugo, A., 2007. The evaluation of oil and fatty acid composition in seed of cotton from various countries. Journal of the Science of Food and Agriculture 87(2): 340–347.

Luoga, E.J., Witkowski, E.T.F. & Balkwill, K., 2000. Differential utilization and ethnobotany of trees in Kitulanghalo forest reserve and surrounding communal lands, eastern Tanzania. Economic Botany 54(3): 328–343.

Luoga, E.J., Witkowski, E.T.F. & Balkwill, K., 2004. Regeneration by coppicing (resprouting) of miombo (African savanna) trees in relation to land use. Forest Ecology and Management 189: 23–35.

Lusigi, W.J., Nkurunziza, E.R. & Masheti, S., 1984. Forage preferences of livestock in the arid lands of northern Kenya. Journal of Range Management 37(6): 542–548.

Lütge, B.U., Hardy, M.B. & Hatch, G.P., 1998. Soil and sward characteristics of patches and non-patches in the Highland Sourveld of South Africa. Tropical Grasslands 32(1): 64–71.

Lwoga, C.M.F., 1987. Historical roots of the labour shortage problem in the sisal industry in Tanzania: contradictions of the cheap labour system. Journal of Eastern African Research and Development 17: 18–33.

Lye, K.A., 1981. Studies in African Cyperaceae 20. New taxa and combinations in Pycreus Beauv. Nordic Journal of Botany 1: 617–622.

Lye, K.A., 1992. The history of the genus Mariscus (Cyperaceae). Lidia 3: 37–72.

Lye, K.A., 1994. The family Marantaceae in Ethiopia. Lidia 3(4): 123–130.

Lye, K.A., 1995a. Cyperaceae. In: Thulin, M. (Editor). Flora of Somalia. Volume 4. Angiospermae (Hydrocharitaceae-Pandanaceae). Royal Botanic Gardens, Kew, Richmond, United Kingdom. pp. 98–147.

Lye, K.A., 1995b. Juncaceae. In: Thulin, M. (Editor). Flora of Somalia. Volume 4. Angiospermae (Hydrocharitaceae-Pandanaceae). Royal Botanic Gardens, Kew, Richmond, United Kingdom. pp. 95–98.

Lye, K.A., 1996. A new subspecies of Bulbostylis hispidula (Cyperaceae) from Somalia. Willdenowia 25(2): 595–600.

Lye, K.A., 1997a. Cyperaceae. In: Edwards, S., Mesfin Tadesse, Demissew Sebsebe & Hedberg, I. (Editors). Flora of Ethiopia and Eritrea. Volume 6. Hydrocharitaceae to Arecaceae. The National Herbarium, Addis Ababa University, Addis Ababa, Ethiopia and Department of Systematic Botany, Uppsala University, Uppsala, Sweden. pp. 391–511.

Lye, K.A., 1997b. Typhaceae. In: Edwards, S., Mesfin Tadesse, Demissew Sebsebe & Hedberg, I. (Editors). Flora of Ethiopia and Eritrea. Volume 6. Hydrocharitaceae to Arecaceae. The National Herbarium, Addis Ababa University, Addis Ababa, Ethiopia and Department of Systematic Botany, Uppsala University, Uppsala, Sweden. pp. 383–385.

Lye, K.A., 2003. Schoenoplectiella Lye, gen. nov. (Cyperaceae). Lidia 6(1): 20–29.

Lye, K.A. & Edwards, S., 1997. Velloziaceae. In: Edwards, S., Mesfin Tadesse, Demissew Sebsebe & Hedberg, I. (Editors). Flora of Ethiopia and Eritrea. Volume 6. Hydrocharitaceae to Arecaceae. The National Herbarium, Addis Ababa University, Addis Ababa, Ethiopia and Department of Systematic Botany, Uppsala University, Uppsala, Sweden. pp. 311–314.

Lye, K.A. & Friis, I., 1997. Marantaceae. In: Edwards, S., Mesfin Tadesse, Demissew Sebsebe & Hedberg, I. (Editors). Flora of Ethiopia and Eritrea. Volume 6. Hydrocharitaceae to Arecaceae. The National Herbarium, Addis Ababa University, Addis Ababa, Ethiopia and Department of Systematic Botany, Uppsala University, Uppsala, Sweden. pp. 335–338.

Lykke, A.M., Mertz, O. & Ganaba, S., 2002. Food consumption in rural Burkina Faso. Ecology of Food and Nutrition 41(2): 119–153.

Lymbery, A.J., Doupé, R.G., Bennett, T. & Starcevich, M.R., 2006. Efficacy of a subsurface-flow wetland using the estuarine sedge Juncus kraussii to treat effluent from inland saline aquaculture. Aquacultural Engineering 34(1): 1–7.

M'bah-Ngami, A.G., 1998. Coûts de production des légumes-feuilles laitue, amarante, corète potagère et morelle noire dans la zone périurbaine de la ville de Yaoundé. Student report, Deschang University, Cameroon.

M'Biandoun, M., Guibert, H. & Olina, J.-P., 2006. Caractérisation de la fertilité du sol en fonction des mauvaises herbes présentes. Tropicultura 24(4): 247–252.

Ma, J.-S., 1992. A taxonomic revision of the genus Aristolochia subgenus Pararistolochia. Acta Phytotaxonomica Sinica 30(6): 508–514.

Mabberley, D.J. & Capuron, R., 1999. Révision des Malvaceae-Grewioideae ('Tiliacées', p.p.) de Madagascar et des Comores. 4. Les Grewia du sous-genre Burretia (Hochr.) Capuron. Adansonia, séries 3, 21(2): 283–300.

MacFoy, C.A. & Sama, A.M., 1983. Medicinal plants in Pujehun district of Sierra Leone. Journal of Ethnopharmacology 8: 215–223.

Macharia, P.N., 2004. Community based interventions as a strategy to combat desertification in the arid and semi-arid rangelands of Kajiado District, Kenya. Environmental Monitoring and Assessment 99: 141–147.

Macharia, P.N. & Ekaya, W.N., 2005. The impact of rangeland condition and trend to the grazing resources of a semi-arid environment in Kenya. Journal of Human Ecology 17(2): 143–147.

MacLachlan, M., 2002. Manual of highland Ethiopian trees and shrubs. SIM Forestry Study Project, Injibara, Ethiopia. 381 pp.

Maclean, I.M.D., Tinch, R., Hassall, M. & Boar, R.R., 2003a. Social and economic use of wetland resources: a case study from Lake Bunyonyi, Uganda. Environmental Change and Management Working Paper No 2003–09. Centre for Social and Economic Research into the Global Environment, University of East Anglia, Norwich, United Kingdom. 20 pp.

Maclean, I.M.D., Tinch, R., Hassall, M. & Boar, R.R., 2003b. Towards optimal use of tropical wetlands: an economic evaluation of goods derived from papyrus swamps in southwest Uganda. Environmental Change and Management Working Paper No 2003–10, Centre for Social and Economic Research into the Global Environment, University of East Anglia, Norwich, United Kingdom. 21 pp.

Maddison, M., Mauring, T., Remm, K., Lesta, M. & Mander, U., 2009. Dynamics of Typha latifolia L. populations in treatment wetlands in Estonia. Ecological Engineering 35: 258–264.

Maggioni, L., Pavelek, M., van Soest, L.J.M. & Lipman, E., 2002. Flax genetic resources in Europe. Ad hoc meeting, 7–8 December 2001, Prague, Czech Republic. International Plant Genetic Resources Institute, Rome, Italy. 80 pp.

Mahapatra, A.K. & Saha, A., 2008. Genetic resources of jute and allied fibre crops. In: Hazra, S.K. and Karmakar, P.G. (Editors). Jute and allied fibre updates: production and technology. Central Research Institute for Jute and Allied Fibres, Barrackpore, India. pp. 18–37.

Mahmoud, M.A., Khidir, M.O., Khalifa, M.A., Bashir el Amadi, A.M., Musnad, H.A.R. & Mohamed, E.T.I., 1995. Sudan: Country Report to the FAO International Technical Conference on Plant Genetic Resources (Leipzig 1996). Khartoum, Sudan. 86 pp.

Maisels, F.G., Cheek, M. & Wild, C., 2000. Rare plants on Mount Oku summit, Cameroon. Oryx 34: 136–140.

Maitai, C.K., Talalaj, S., Talalaj, D. & Njoroge, D., 1981. Smooth muscle stimulating substances in the stinging nettle tree Obetia pinnatifida. Toxicon 19(1): 186–188.

Maite, A.L., 1987. Some Malvaceae of Mozambique with medicinal properties. In: Leeuwenberg, A.J.M. (compiler). Medicinal and poisonous plants of the tropics. Proceedings of Symposium 5–35 of the 14th International Botanical Congress, Berlin, 24 July – 1 August 1987.Pudoc, Wageningen, Netherlands. pp. 116–118.

Maiti, R.K., 1967. Hibiscus vitifolius, a new fibre crop. Economic Botany 23(2): 141–147.

Maiti, R.K., 1979. A study of the microscopic structure of the fiber strands of common Indian bast fibers and its economic implications. Economic Botany 33(1): 78–87.

Maiti, R., 1997. World fiber crops. Science Publishers, Enfield, New Hampshire, United States. 208 pp.

Maiti, R.K. & Chakravarty, K., 1977. A comparative study of yield components and quality of common Indian bast fibres. Economic Botany 31: 55–60.

Maity, S. & Datta, A.K., 2009. Karyomorphology in nine species of Jute (Corchorus L., Tiliaceae). Cytologia 74(3): 273–279.

Maity, S., Datta, A.K. & Chattopadhyay, A., 2009. Seed protein polymorphism in nine species of Jute (Corchorus, Family: Tiliaceae). Indian Journal of Science and Technology 2(1): 34–36.

Majaja, B.A. & Chancellor, W.J., 1997. The potential for mechanical harvest of sisal. Applied Engineering in Agriculture 13(6): 703–708.

Mal, T.K. & Narine, L., 2004. The biology of Canadian weeds. 129. Phragmites australis (Cav.) Trin. ex Steud. Canadian Journal of Plant Science 84: 365–396.

Malaisse, F., 1997. Se nourir en fôret claire africaine. Approche écologique et nutritionelle. Les presses agronomiques de Gembloux, Gembloux, Belgium & CTA, Wageningen, Netherlands. 384 pp.

Malaisse, F. & Parent, G., 1985. Edible wild vegetable products in the Zambezian woodland area: a nutritional and ecological approach. Ecology of Food and Nutrition 18: 43–82.

Malan, J.S. & Owen-Smith, G.L., 1974. The ethnobotany of Kaokoland. Cimbebasia B2: 131–178.

Malan, E. & Pienaar, D.H., 1987. (+)-catechin-galloyl esters from the bark of Acacia gerrardii. Phytochemistry 26(7): 2049–2051.

Malla Reddy, V., Reddy, M.M. & Reddy, S.M., 1981. Antibacterial activity of leaf extracts of Gossypium herbaceum. Geobios 8(6): 277–278.

Mallick, S., Ghosh, P., Samanta, S.K., Kinra, S., Pal, B.C., Gomes, A. & Vedasiromoni, J.R., 2010. Corchorusin-D, a saikosaponin-like compound isolated from Corchorus acutangulus Lam., targets mitochondrial apoptotic pathways in leukemic cell lines (HL-60 and U937). Cancer Chemotherapy and Pharmacology 66(4): 709–719.

Manandhar, N.P., 1995. A survey of medicinal plants of Jajarkot district, Nepal. Journal of Ethnopharmacology 48(1): 1–6.

Mandibaya, W. & Chihora, R.M., 1999. The nutritional value of Piliostigma thonningii (Mutukutu, monkey bread) pods as a feed supplement for communal cattle in Zimbabwe. Animal Feed Science and Technology 78(3–4): 287–295.

Mangenot, G., 1965. Marantochloa purpurea (Ridl.) Milne-Redh. Icones Plantarum Africanarum 7, No 160. 4 pp.

Mangenot, S. & Mangenot, G., 1957. Nombres chromosomiques nouveaux chez diverses Dicotyledones et Monocotyledones d'Afrique occidentale. Bulletin du Jardin Botanique de l'Etat (Bruxelles) 27(4): 639–654.

Mangenot, S. & Mangenot, G., 1958. Deuxième liste de nombres chromosomiques nouveaux chez diverses Dicotyledones et Monocotyledones d'Afrique occidentale. Bulletin du Jardin Botanique de l'Etat (Bruxelles) 28(4): 315–329.

Mann, A., Ifarajimi, O.R., Adewoye, A.T., Ukam, C., Udeme, E.E., Okorie, I.I., Sakpe, M.S., Ibrahim, D.R., Yahaya, Y.A., Kabir, A.Y. & Ogbadoyi, E.O., 2011. In vivo antitrypanosomal effects of some ethnomedicinal plants from Nupeland of North Central Nigeria. African Journal of Traditional, Complementary and Alternative Medicines 8(1): 15–21.

Mansfeld, R., 1986. Verzeichnis landwirtschaftlicher und gärtnerischer Kulturpflanzen (ohne Zierpflanzen). 2nd edition, revised by J. Schultze-Motel. 4 volumes. Springer Verlag, Berlin, Germany. 1998 pp.

Marais, A., 1973. A revision of the tropical species of Kniphofia (Liliaceae). Kew Bulletin 28: 465–483.

Marais, W., 1984. Notes on Mascarene Malvaceae. Kew Bulletin 38: 41–46.

Marais, W. & Coode, M.J.E., 1978. Agavacées. In: Bosser, J., Cadet, T., Julien, H.R. & Marais, W. (Editors). Flore des Mascareignes. Familles 177–188. The Sugar Industry Research Institute, Mauritius, l'Office de la Recherche Scientifique Outre-Mer, Paris, France & Royal Botanic Gardens, Kew, Richmond, United Kingdom. 9 pp.

Marais, W. & Friedmann, F., 1987. Malvacées. In: Bosser, J., Cadet, T., Guého, J. & Marais, W. (Editors). Flore des Mascareignes. Familles 51–62. The Sugar Industry Research Institute, Mauritius, l'Office de la Recherche Scientifique Outre-Mer, Paris, France & Royal Botanic Gardens, Kew, Richmond, United Kingdom. 57 pp.

Marais, W. & Jellis, S., 1985. Urticacées. In: Bosser, J., Cadet, T., Guého, J. & Marais, W. (Editors). Flore des Mascareignes. Familles 161–169. The Sugar Industry Research Institute, Mauritius, l'Office de la Recherche Scientifique Outre-Mer, Paris, France & Royal Botanic Gardens, Kew, Richmond, United Kingdom. 36 pp.

Markgraf, F., 1976. Apocynaceae. Flore de Madagascar et des Comores, famille 169. Muséum National d'Histoire Naturelle, Paris, France. 318 pp.

Marks, M. & Randall, J., 1994. Phragmites australis (P. communis): threats, management, and monitoring. Natural Areas Journal 14: 285–294.

Markström, C., 1977. Plantes médicinales congolaises. Mémoire de fin d'études, Upsala, Sweden. 60 pp.

Martin, E.A., Ratsimisetra, Laloë, F. & Carrière, S.M., 2009. Conservation value for birds of traditionally managed isolated trees in an agricultural landscape of Madagascar. Biodiversity and Conservation 18: 2719–2742.

Martin, F.W., Campbell, C.W. & Ruberté, R.M., 1987. Perennial edible fruits of the tropics: an inventory. Agriculture Handbook No 642. USDA, Agricultural Research Service, Washington D.C., United States. 247 pp.

Masika, P.J. & Afolayan, A.J., 2003. An ethnobotanical study of plants used for the treatment of livestock diseases in the Eastern Cape Province, South Africa. Pharmaceutical Biology 41(1): 16–21.

Mason, O.T., 1988. American Indian basketry. Dover Publications, Mineola, New York, United States. 529 pp.

Masters, M.T., 1868a. Malvaceae. In: Oliver, D. (Editor). Flora of tropical Africa. Volume 1. L. Reeve & Co, Ashford, United Kingdom. pp. 175–214.

Masters, M.T., 1868b. Tiliaceae. In: Oliver, D. (Editor). Flora of tropical Africa. Volume 1. L. Reeve & Co, Ashford, United Kingdom. pp. 240–268.

Matavele, J. & Habib, M., 2000. Ethnobotany in Cabo Delgado, Mozambique: use of medicinal plants. Environment, Development and Sustainability 2: 227–234.

Matlebyane, M.M., Ng'ambi, J.W.W. & Aregheore, E.M., 2009. Relationships between chemical composition and in vitro digestibility of some common forage species used for ruminant livestock production in three chief areas of Capricorn Region, Limpopo province, South Africa. Research Journal of Agriculture and Biological Sciences 5(2): 138–149.

Matlebyane, M.M., Ng'ambi, J.W.W. & Aregheore, E.M., 2010. Indigenous knowledge (IK) ranking of available browse and grass species and some shrubs used in medicinal and ethno veterinary practices in ruminant livestock production in Limpopo province, South Africa. Livestock Research for Rural Development 22(3): 54.

Matolweni, L.O. & McLellan, T., 1997. Genetic diversity of an exploited species, Flagellaria guineensis. South African Journal of Botany 63: 294–298.

Matsunaga, K., Shibuya, M. & Ohizumi, Y., 1994a. Cylindrene, a novel sesquiterpenoid from Imperata cylindrica with inhibitory activity on contractions of vascular smooth muscle. Journal of Natural Products 57(8): 1183–1184.

Matsunaga, K., Shibuya, M. & Ohizumi, Y., 1994b. Graminone B, a novel lignan with vasodilative activity from Imperata cylindrica. Journal of Natural Products 57(12): 1734–1736.

Matsunaga, K., Shibuya, M. & Ohizumi, Y., 1995. Imperanene, a novel phenolic compound with platelet aggregation inhibitory activity from Imperata cylindrica. Journal of Natural Products 58(1): 138–139.

Matsunaga, K., Ikeda, M., Shibuya, M. & Ohizumi, Y., 1994. Cylindol, a novel biphenyl ether with 5-lipoxygenase inhibitory activity, and a related compound from Imperata cylindrica. Journal of Natural Products 57(9): 1290–1293.

Matthews, G.A. & Tunstall, J.P., 2006. Smallholder cotton production in sub-Saharan Africa: an assessment of the way forward. International Journal of Pest Management 52(3): 149–153.

Matthews, G.A. & Tunstall, J.P. (Editors), 1994. Insect pests of cotton. CAB International, Wallingford, United Kingdom. 593 pp.

Mauersberger, H.R. (Editor), 1954. Textile fibers: their physical, microscopic and chemical properties. 6th Edition. John Wiley & Sons, New York, United States. 1283 pp.

Maundu, P., Berger, D., Saitabau, C., Nasieku, J., Kipelian, M., Mathenge, S., Morimoto, Y. & Höft, R., 2001. Ethnobotany of the Loita Maasai. Towards community management of the forest of the Lost Child. Experiences from the Loita Ethnobotany Project. UNESCO People and Plants Working Paper 8, Paris, France. 34 pp.

Mazodze, R. & Conlong, D.E., 2003. Eldana saccharina (Lepidoptera: Pyralidae) in sugarcane (Saccharum hybrids), sedge (Cyperus digitatus) and bulrush (Typha latifolia) in south-eastern Zimbabwe. Proceedings of the South African Sugar Technology Association 77: 266–274.

Mbuligwe, S.E., 2004. Comparative effectiveness of engineered wetland systems in the treatment of anaerobically pre-treated domestic wastewater. Ecological Engineering 23: 269–284.

Mbuya, L.P., Msanga, H.P., Ruffo, C.K., Birnie, A. & Tengnäs, B., 1994. Useful trees and shrubs for Tanzania: identification, propagation and management for agricultural and pastoral communities. Technical Handbook 6. Regional Soil Conservation Unit/SIDA, Nairobi, Kenya. 542 pp.

McCaleb, R., 2000. Roselle production manual (Hibiscus sabdariffa). [Internet]. ASNAPP, Herb Research Foundation, Boulder CO, United States. <http://www.herbs.org/africa/hibiscus_production_manual.html>. Accessed June 2004.

McDougall, G.J., Morrison, I.M., Stewart, D., Weyers, J.D.B. & Hillman, J.R., 1993. Plant fibres: botany, chemistry and processing for industrial use. Journal of the Science of Food and Agriculture 62(1): 1–20.

McKean, S.G., 2001. Productivity and sustainable use of Phragmites in the Fuyeni reedbed, Hluhluwe-Umfolozi Park: management guidelines for harvest. South African Journal of Botany 67(2): 274–280.

McKee, J. & Richards, A.J., 1996. Variation in seed production and germinability in common reed (Phragmites australis) in Britain and France with respect to climate. New Phytologist 133: 233–243.

McLaughlin, S.P. & Schuck, S.M., 1991. Fiber properties of several species of Agavaceae from the southwestern United States and northern Mexico. Economic Botany 45(4): 480–486.

McVaugh, R., 1974. Report of the Committee for Spermatophyta: conservation of generic names 17. Proposal 315 (post 278) Loudetia Hochstetter ex Steudel (1854) vs. Loudetia A. Braun (1841). Taxon 23 (5–6): 819.

Mecha, I. & Adegbola, T.A., 1980. Chemical composition of some southern Nigeria forage eaten by goats. [Internet] In: Le Houérou, H.N. (Editor), 1980. Browse in Africa: the current state of knowledge. International Livestock Centre for Africa, Addis Ababa, Ethiopia. <http://www.ilri.org/ InfoServ/Webpub/fulldocs/BROWSE_IN_AFRICA/ Chapter30.htm>. Accessed August 2011.

Medina, J.C., 1959. Plantas fibrosas da flora mundial. Instituto Agronômico Campinas, Sao Paulo, Brazil. 913 pp.

Medley, K.E., 1993. Extractive forest resources of the Tana River national primate reserve, Kenya. Economic Botany 47(2): 171–183.

Medley, K.E. & Kalibo, H.W., 2007. Ethnobotanical survey of 'wild' woody plant resources at Mount Kasigau, Kenya. Journal of East African Natural History 96(2): 149–186.

Meimberg, H., Dittrich, P., Bringmann, G., Schlauer, J. & Heubl, G., 2000. Molecular phylogeny of Caryophyllidae s.l. based on matK sequences with special emphasis on carnivorous taxa. Plant Biology 2: 218–228.

Melaku, S., Aregawi, T. & Nigatu, L., 2010. Chemical composition, in vitro dry matter digestibility and in sacco degradability of selected browse species used as animal feeds under semi-arid conditions in northern Ethiopia. Agroforestry Systems 80(2): 173–184.

Mellet, M.A., Schoeman, A.S. & Broodryk, S.W., 2003. Review of insect pest management strategies for the organic cultivation of cotton. African Plant Protection 9(2): 61–86.

Melzer, S.E., Knapp, A.K., Kirkman K.P., Smith, M.D., Blair, J.M. & Kelly, E.F., 2010. Fire and grazing impacts on silica production and storage in grass dominated ecosystems. Biogeochemistry 97: 263–278.

Mena Lopez, S., 2002. Papyrus conservation around Lake Naivasha. MSc thesis. International Institute for Geo-information Science and Earth Observation, Enschede, Netherlands. 86 pp.

Mendiola, N.B., 1917. A study of Philippine bast fibers. The Philippine Agriculturist and Forester 6: 6–39.

Mensah, A.Y., Donkor, P.O. & Fleischer, T.C., 2011. Anti-inflammatory and antioxidant activities of the leaves of Wissadula amplissima var. rostrata. African Journal of Traditional, Complementary and Alternative Medicines 8(2): 185–195.

Menut, C., Lamaty, G., Bessière, J.M. & Koudou, J., 1994. Aromatic plants of tropical central Africa. 13. Rhizome volatile components of two Zingiberales from the Central African Republic. Journal of Essential Oil Research 6(2): 161–164.

Menzel, M.Y. & Pate, J.B., 1960. Chromosomes and crossing behavior of some species of Sansevieria. American Journal of Botany 47(3): 230–238.

Mertz, O., Lykke, A.M. & Reenberg, A., 2001. Importance and seasonality of vegetable consumption and marketing in Burkina Faso. Economic Botany 55: 276–289.

Merxmüller, H. & Schreiber, A., 1968. Pedaliaceae. Prodromus einer Flora von Südwestafrika. No 131. J. Cramer, Germany. 13 pp.

Metcalfe, C.R., 1951. The anatomical structure of the Dioncophyllaceae in relation to the taxonomic affinities of the family. Kew Bulletin 3: 351–368.

Mevy, J.P., Bessiere, J.M., Rabier, J., Dherbomez, M., Ruzzier, M., Millogo, J. & Viano, J., 2006. Composition and antimicrobial activities of the essential oil of Triumfetta rhomboidea Jacq. Flavour and Fragrance Journal 21(1): 80–83.

Miao, S.L., Kong, L., Lorenzen, B. & Johnson, R.R., 1998. Versatile modes of propagation in Cladium jamaicense in the Florida Everglades. Annals of Botany 82: 285–290.

Michelan, V.S. & Vanzela, A.L.L., 2009. Estudo citogenético em espécies da família Cyperaceae Juss. Resumos do 55° Congresso Brasileiro de Genética, 30 de agosto a 02 de setembro de 2009, Centro de Convenções do Hotel Monte Real Resort, Águas de Lindóia, São Paulo, Brasil. p. 8.

Miguet, J.-M., 1955. Boisement et régéneration de forêts reliques en zone tropicale humide: les forêts de Saint-Philippe a la Réunion. Revue Forestière Française 7(3): 187–200.

Mildbraed, J., 1934. Neue und seltene Arten aus Ostafrika (Tanganyika-Territ. Mandat) V. Notizblatt des botanischen Gartens und Museums zu Berlin-Dahlem 11(110): 1058–1092.

Miller, K.I. & Webster, G.L., 1966. Chromosome numbers in the Euphorbiaceae. Brittonia 18: 372–379.

Milne-Redhead, E., 1950. Notes on African Marantaceae I. Kew Bulletin 5(2): 157–163.

Milne-Redhead, E., 1952. Marantaceae. In: Turrill, W.B. & Milne-Redhead, E. (Editors). Flora of Tropical East Africa. Crown Agents for Oversea Governments and Administrations, London, United Kingdom. 11 pp.

Milton, S.J. & Dean, W.R.J., 2001. Seeds dispersed in dung of insectivores and herbivores in semi-arid southern Africa. Journal of Arid Environments, 47: 465–483.

Missengoula, T.H., 2004. Contribution à l'étude des produits forestiers non ligneux : exemple de la commercialisation des feuilles d'emballage de manioc dans les marchés de Libreville. Rapport de fin de cycle pour l'obtention du diplôme d'Agent Technique des Eaux et Forêts. Direction des Etudes, Ecole Nationale des Eaux et Forêts (E. N. E. F), Cap-Estérias, Gabon. 23 pp.

Missouri Botanical Garden, undated. VAST (VAScular Tropicos) nomenclatural database. [Internet] <http://mobot.mobot.org/ W3T/Search/ vast.html>. Accessed July 2009 - August 2011.

Mitei, Y.C., Ngila, J.C., Yeboah, S.O., Wessjohann, L. & Schmidt, J., 2008. Profiling of phytosterols, tocopherols and tocotrienols in selected seed oils from Botswana by GC-MS and HPLC. Journal of the American Oil Chemists' Society 86: 617–625.

Mitei, Y.C., Ngila, J.C., Yeboah, S.O., Wessjohann, L. & Schmidt, J., 2009. NMR, GC-MS and ESI-FTICR-MS profiling of fatty acids and triacylglycerols in some Botswana seed oils. Journal of the American Oil Chemists' Society 85(11): 1021–1032.

Mmopelwa, G., 2006. Economic and financial analysis of harvesting and utilization of river reed in the Okavango Delta, Botswana. Journal of Environmental Management 79: 329–335.

Mnaya, B., Asaeda, T., Kiwango, Y. & Ayubu, E., 2007. Primary production in papyrus (Cyperus papyrus L.) of Rubondo Island, Lake Victoria, Tanzania. Wetlands Ecology and Management 15(4): 269–275.

Mndolwa, M.A., Lulandala, L.L.L. & Elifuraha, E., 2008. Evaluation of tree species enumerated in Kitulangalo Mitmiombo plots by uses and benefits. Working Papers of the Finnish Forest Research Institute 98: 5–9.

Moerman, D.E., 1998. Native American ethnobotany. Timber Press, Portland, Oregon, United States. 933 pp.

Moggi, M.A., 1994. Utilisation des arbres et arbustes dans deux bassins-versants au sud de Miarinarivo. Rapport de stage, Département des Eaux et Forêts, Ecole Supérieure des Sciences Agronomiques, Université d'Antananarivo, Antananarivo, Madagascar. 26 pp.

Mohamed, A.A., Khalil, A.A. & El-Beltagi, H.E.S., 2010. Antioxidant and antimicrobial properties of kaff maryam (Anastatica hierochuntica) and doum palm (Hyphaene thebaica). Grasas y Aceites 61(1): 67–75.

Mohanan, C., 1993. Biodeterioration of post-harvest rattans. In: Rattan management and utilization. Proceedings of a seminar, Trichur, India, 1992. Kerala Forest Research Institute, Peechi, India. pp. 266–280.

Montagu, K.D., Kearney, D.E. & Smith, R.G.B., 2003. The biology and silviculture of pruning planted eucalypts for clear wood production – a review. Forest Ecology and Management 179(1–3): 1–13.

Moore, H.E. & Guého, L.J., 1984. Palmiers. In: Bosser, J., Cadet, T., Guého, J. & Marais, W. (Editors). Flore des Mascareignes. Famille 189. The Sugar Industry Research Institute, Mauritius, l'Office de la Recherche Scientifique Outre-Mer, Paris, France & Royal Botanic Gardens, Kew, Richmond, United Kingdom. 34 pp.

Morakinyo, A.B., 1995a. Profiles and pan-African distributions of the rattan species (Calamoideae) recorded in Nigeria. Principes 39(4): 197–209.

Morakinyo, A.B., 1995b. The commercial rattan trade in Nigeria forests. Trees and People Newsletter 25: 22–30.

Morelli, C.F., Cairoli, P., Speranza, G., Alamgir, M. & Rajia, S., 2006. Triglycerides from Urena lobata. Fitoterapia 77: 296–299.

Morgenthal, T., Maboeta, M. & van Rensburg, L., 2004. Revegetation of heavy metal contaminated mine dumps using locally serpentine-adapted grass species. South African Journal of Botany 70(5): 784–789.

Morris, B., 1996. Chewa medical botany. A study of herbalism in southern Malawi. Monographs from the International African Institute. LIT Verlag/Transaction, London, United Kingdom. 557 pp.

Morris, J.B., 1997. Special-purpose legume genetic resources conserved for agricultural, industrial, and pharmaceutical use. Economic Botany 51(3): 251–263.

Morris, D.H., 2004. Flax – A health and nutrition primer. [Internet] <http://www.flaxcouncil.ca>. Accessed July 2005.

Morris, J.B. & Kays, S.E., 2005. Total dietary fiber variability in a cross section of Crotalaria juncea genetic resources. Crop Science 45(5): 1826–1829.

Morse, S., Bennett, R. & Ismael, Y., 2005. Bt-cotton boosts the gross margin of small-scale cotton producers in South Africa. International Journal of Biotechnology 7(1–3): 72–83.

Morton, J.F., 1975. Cattails (Typha spp.): weed problem or potential crop. Economic Botany 29(1): 7–29.

Morton, J.F. & Dowling, C.F., 1987. In: Fruits of warm climates. [Internet] Julia F. Morton, Miami, United States. 505 pp. <http://www.hort.purdue.edu/ newcrop/morton/ roselle.html>. Accessed June 2004.

Moshi, M.J. & Mbwambo, Z.H., 2002. Experience of Tanzanian traditional healers in the management of non-insulin dependent diabetes mellitus. Pharmaceutical Biology 40(7): 552–560.

Motte, E., 1980. A propos des thérapeutiques Pygmées Aka de la région de la Lobaye (Centrafrique). Journal d'Agriculture Traditionnelle et de Botanique Appliquée 27(2): 113–132.

Mouranche, R., 1955. Le palmier-raphia de Madagascar. Bois et Forêts des Tropiques 41: 8–22.

Moussa, H., Margolis, H.A., Dube, P.-A. & Odongo, J., 1998. Factors affecting the germination of doum palm (Hyphaene thebaica Mart.) seeds from the semi-arid zone of Niger, West Africa. Forest Ecology and Management 104(1–3): 27–41.

Mpiana, P.T., Tshibangu, D.S., Shetonde, O.M. & Ngbolua, K.N., 2007. In vitro antidrepanocytary activity (anti-sickle cell anemia) of some Congolese plants. Phytomedicine 14(2–3): 192–195.

Msafiri, H.B., 1987. 'Kaptura' problem of sisal industry in Tanzania. TARO Newsletter 2(2): 5–7.

Muanza, D.N., Dangala, N.L. & Mpay, O., 1993. Zairean medicinal plants as diarrhea remedies and their antibacterial activities. African Study Monographs 14(1): 53–63.

Muanza, D.N., Euler, K.L., Williams, L. & Newman, D.J., 1995. Screening for antitumor anti-HIV activities of nine medicinal plants from Zaire. International Journal of Pharmacognosy 33: 98–106.

Mucunguzi, P., 1995. Effects of bruchid beetles on germination and establishment of Acacia species. African Journal of Ecology 33(1): 64–70.

Mugisha, P., Kansiime, F., Mucunguzi, P. & Kateyo, E., 2007. Wetland vegetation and nutrient retention in Nakivubo and Kirinya wetlands in the Lake Victoria basin of Uganda. Physics and Chemistry of the Earth 32: 1359–1365.

Muhammad Mansur, 2001. Merremia Dennst. ex Endl. In: van Valkenburg, J.L.C.H. & Bunyapraphatsara, N. (Editors). Plant Resources of South-East Asia No 12(2): Medicinal and poisonous plants 2. Backhuys Publishers, Leiden, Netherlands. pp. 366–373.

Muhwezi, O., Cunningham, A.B. & Bukenya-Ziraba, R., 2009. Lianas and livelihoods: the role of fibrous forest plants in food security and society around Bwindi Impenetrable National Park, Uganda. Economic Botany 63(4): 340–352.

Muir, A.D. & Westcott, N.D. (Editors), 2003. Flax: the genus Linum. Routledge, London, United Kingdom. 307 pp.

Mukherjee, I., 1969. Studies on flowering responses of Urena lobata. Plant Physiology 44(12): 1749–1751.

Mukherjee, K.S. & Badruddoja, S., 1977. Chemical investigation of the heartwood of Abroma augusta Linn. f. Current Science 47(9): 301.

Müller, M.A.N., 1984. Grasses of South West Africa/Namibia. Directorate of Agriculture and Forestry, Department of Agriculture and Nature Conservation, Windhoek, Namibia. 287 pp.

Müller, J.V., 2005. Ephemeral vegetation at shorelines of Sahelian seasonal lakes. Systematics and Geography of Plants 75: 239–257.

Munawar, S.S., Umemura, K. & Kawai, S., 2007. Characterization of the morphological, physical, and mechanical properties of seven nonwood plant fiber bundles. Journal of Wood Science 53(2): 108–113.

Munirajappa & Krishnappa, D.G., 1993. Cytotaxonomic studies in some south Indian species of Abutilon. Journal of Cytology and Genetics 28: 71–76.

Muoghalu, J.I. & Okeesan, O.O., 2005. Climber species composition, abundance and relationship with trees in a Nigerian secondary forest. African Journal of Ecology 43(3): 258–266.

Muoghalu, J.I., Akanni, S.O. & Eretan, O.O., 1993. Litter fall and nutrient dynamics in a Nigerian rain forest seven years after a ground fire. Journal of Vegetation Science 4: 323–328.

Murali, R., 1990. Pulping and fiber characteristics of non-woody plants in Kenya. In: Kennedy, J.F., Phillips, G.O. & Williams, P.A. (Editors). Cellulose sources and exploitation: industrial utilization, biotechnology and physico-chemical properties. Ellis Horwood, New York, United States. pp. 89–94.

Muregi, F.W., Chhabra, S.C., Njagi, E.N.M., Lang'at Thoruwa, C.C., Njue, W.M., Orago, A.S.S., Omar, S.A. & Ndiege, I.O., 2003. In vitro antiplasmodial activity of some plants used in Kisii, Kenya against malaria and their chloroquine potentiation effects. Journal of Ethnopharmacology 84(2–3): 235–239.

Muthuri, F., 1992. Plant products from freshwater wetlands. In: Crafter, S.A., Njuguna, S.G. & Howard, G.W. (Editors). Wetlands of Kenya. Proceedings of the KWWG Seminar on Wetlands of Kenya, National Museums of Kenya, Nairobi, Kenya, 3–5 July 1991. IUCN, Nairobi, Kenya. 183 pp.

Muthuri, F.M & Kinyamario, J.I., 1989. Nutritive value of papyrus (Cyperus papyrus, Cyperaceae), a tropical emergent macrophyte. Economic Botany 43(1): 23–30.

Mwachala, G. & Mbugua, P.K., 2007. Dracaenaceae. In: Beentje, H.J. & Ghazanfar, S.A. (Editors). Flora of Tropical East Africa. Royal Botanic Gardens, Kew, Richmond, United Kingdom. 43 pp.

Mwaikambo, L.Y., 2006. Review of the history, properties and application of plant fibres. African Journal of Science and Technology, Science and Engineering Series 7(2): 120–133.

Mwihomeke, S.T., Zilihona, I.J.E., Hamisy, W.C. & Mwaseba, D., 2000. Assessment of forest user groups and their relationship to the condition of the natural forests in the Uluguru Mountains. Wildlife Conservation Society of Tanzania (WCST), Uluguru Mountains Biodiversity Conservation Project, Morogoro, Tanzania. 57 p.

Myalyosi, R.B.B., 1992. Influence of livestock grazing on range condition in south-west Masailand, northern Tanzania. Journal of Applied Ecology 29(3): 581–588.

N'goran, A., Goli, K., Abdourahamane, S. & Alassane, S., 1995. Côte d'Ivoire: Rapport de pays pour la conférence technique internationale de la FAO sur les ressources phytogénétiques. FAO, Abidjan, Cote d'Ivoire. 75 pp.

Nabakooza, J., 2003. Illustration Hibiscus cannabinus L. Unpublished.

Nacoulma-Ouédraogo, O., Millogo-Rasolodimby, J. & Guinko, S., 1998. Les plantes herbacées dans la thérapie des piqûres d'insectes. Revue de médecines et pharmacopées africaines 11–12: 165–175.

Nacro, M. & Millogo-Rasolodimbi, J., 1993. Plantes tinctoriales et plantes à tanins du Burkina Faso. Editions ScientifikA, Amiens, France. 152 pp.

Nagasaki, M.S., 2005. Transmission of environmental and conservation knowledge in Andohahela. National Park. SIT Graduate Institute / SIT Study Abroad. [Internet] <http://digitalcollections.sit.edu/ cgi/viewcontent.cgi?article=1458&context=isp_collection>. Accessed

Nahar, L., Ripa, F.A., Rokonuzzaman, M. & Al-Bari, M.A.A., 2009. Investigation on antioxidant activities of six indigenous plants of Bangladesh. Journal of Applied Sciences Research 5(12): 2285–2288.

Nahar, L., Ripa, F.A., Rokonuzzaman, M., Zulfiker, A.H.M., Haque, M. & Islam, K.M.S., 2010. Comparative study of antidiabetic effect of Abroma augusta and Syzygium cumini on alloxan induced diabetic rat. Agriculture and Biology Journal of North America 1(6): 1268–1272.

Naidoo, G. & Kift, J., 2006. Responses of the saltmarsh rush Juncus kraussii to salinity and waterlogging. Aquatic Botany 84(3): 217–225.

Nair, A.G.R., Seetharaman, T.R., Voirin, B. & Favre-Bonvin, J., 1986. True structure of triumboidin, a flavone glycoside from Triumfetta rhomboidea. Phytochemistry 25(3): 768–769.

Nana, C., Brouwer, I.D. & Traoré, A.S., 2003. Consommation alimentaire des enfants de 6 à 36 mois en milieu rural en fonction de la disponibilité des aliments riches en vitamine. 2ème Atelier international Voies alimentaires d'amélioration des situations nutritionnelles, Ouagadougou, 23–28 November 2003. pp. 251–260.

Napper, D.M., 1971a. Flagellariaceae. In: Milne-Redhead, E. & Polhill, R.M. (Editors). Flora of Tropical East Africa. Crown Agents for Oversea Governments and Administrations, London, United Kingdom. 3 pp.

Napper, D.M., 1971b. Typhaceae. In: Milne-Redhead, E. & Polhill, R.M. (Editors). Flora of Tropical East Africa. Crown Agents for Oversea Governments and Administrations, London, United Kingdom. 5 pp.

Nash, H. & Stroupe, S., 2003. Complete guide to water garden plants. Sterling Publishing, New York, United States. 224 pp.

National Medicinal Plants Board, 2008. Agro-techniques of selected medicinal plants. Vol. 1. TERI Press, New Delhi, India. 240 pp.

Nature Protection Trust of Seychelles, 1998. Lodoicea maldivica. In: IUCN. Red list of threatened species. Version 2010.4. [Internet] <http://www.iucnredlist.org>. Accessed December 2010.

Nava, J.N., 1951. Las plantas espontáneas útiles y perjudiciales de Guinea Española (1). Farmacognosia 11: 183–208.

Ndabaneze, P., Engels, D. & Kavamahanga, P.C., 1996. Etude des effets des plantes molluscicides de la flore naturelle du Burundi sur Biomphalaria pfeifferi, hôte intermédiaire de la bilharziose. In: van der Maesen, L.J.G., van der Burgt, X.M. & van Medenbach de Rooy, J.M. (Editors). The biodiversity of African plants. Kluwer, Dordrecht, Netherlands. pp. 757–760.

Ndangalasi, H.J., Bitariho, R. & Dovie, D.B.K., 2007. Harvesting of non-timber forest products and implications for conservation in two montane forests of East Africa. Biological Conservation 134(2): 242–250.

Ndlovu, L.R. & Nherera, F.V., 1997. Chemical composition and relationship to in vitro gas production of Zimbabwean browseable indigenous tree species. Animal Feed Science and Technology 69: 121–129.

Ndon, B.A., 1985. Some morphological and chemical characteristics of developing fruits of Raphia hookeri. Journal of Experimental Botany 36(172): 1817–1830.

Ndounga, M., Mpati, J., Chen Jian, M., Zhou Yuan, P., Bilala, J.P., Sianard, D.F. & Koubemba, M.C., 1991. Etude préliminaire de l'activité antibactérienne de quelques plantes médicinales de la flore Congolaise. Revue de Médecines et Pharmacopées Africaines 5(1): 33–42.

Negesse, T., Makkar, H.P.S. & Becker, K., 2009. Nutritive value of some non-conventional feed resources of Ethiopia determined by chemical analyses and an in vitro gas method. Animal Feed Science and Technology 154: 204–217.

Neinhuis, C., Wanke, S., Hilu, K.W., Müller, K. & Borsch, T., 2005. Phylogeny of Aristolochiaceae based on parsimony, likelihood, and Bayesian analyses of trnL-trnF sequences. Plant Systematics and Evolution 250(1–2): 7–26.

Nelmes, E., 1951. Notes on Cyperaceae, XXVII. Mapania in Africa, I: new Liberian species. Kew Bulletin 6(3): 419–422.

Nelmes, E. & Baldwin, J.T. Jr., 1952. Cyperaceae in Liberia. American Journal of Botany 39(6): 368–393.

Nenonene, A.Y., Kobe, K., Sanda, K. & Rigal, L., 2009. Composition and binding properties of mucilages from stem bark of Grewia venusta and calyx of Bombax costatum, two tropical plants growing wild in Togo. Bangladesh Journal of Scientific and Industrial Research 44(2): 247–253.

Neuwinger, H.D., 1996. African ethnobotany: poisons and drugs. Chapman & Hall, London, United Kingdom. 941 pp.

Neuwinger, H.D., 1998. Afrikanische Arzneipflanzen und Jagdgifte. Chemie, Pharmakologie, Toxikologie. 2nd Edition. Wissenschaftliche Verlagsgesellschaft mbH, Stuttgart, Germany. 960 pp.

Neuwinger, H.D., 2000. African traditional medicine: a dictionary of plant use and applications. Medpharm Scientific, Stuttgart, Germany. 589 pp.

Neuwinger, H.D., 2004. Plants used for poison fishing in tropical Africa. Toxicon 44(4): 417–430.

Newmark, W.D., 2001. Conserving biodiversity in East African forests: a study of the eastern arc mountains. Ecological Studies 155. Springer, Berlin, Germany. 197 pp.

Newton, L.E., 2001. Sansevieria. In: Eggli, U. (Editor). Illustrated handbook of succulent plants: Monocotyledons. Springer-Verlag, Berlin, Germany. pp. 261–272.

Nezomba, H., Tauro, T. P., Mtambanengwe, F. & Mapfumo, P., 2008. Nitrogen fixation and biomass productivity of indigenous legumes for fertility restoration of abandoned soils in smallholder farming systems. South African Journal of Plant and Soil 25(3): 161–171.

Ng, T.B., Chan, W.Y. & Yeung, H.W., 1992. Proteins with abortifacient, ribosome inactivating, immunomodulatory, antitumor and anti-AIDS activities from Cucurbitaceae plants. General Pharmacology 23(4): 579–590.

Ngari, E.W., Chiuri, L.W., Kariuki, S.T. & Huckett, S., 2010. Ethnomedicine of Ogiek of river Njoro watershed, Nakuru – Kenya. Ethnobotany Research & Applications 8: 135–152.

Ngo Bum, E., Taiwe, G.S., Nkainsa, L.A., Moto, F.C.O., Seke Etet, P.F., Hiana, I.R., Bailabar, T., Rouyatou, Papa Seyni, Rakotonirina, A. & Rakotonirina, S.V., 2009. Validation of anticonvulsant and sedative activity of six medicinal plants. Epilepsy & Behavior 14(3): 454–458.

Ngobo, M.P., Weise, S.F. & Mcdonald, M.A., 2004. Revisiting the performance of natural fallows in Central Africa. Scandinavian Journal of Forest Research 19, Supplement 4: 14–24.

Ngodigha, E.M. & Oji, U.I., 2009. Evaluation of fodder potential of some tropical browse plants using fistulated N'dama cattle. African Journal of Agricultural Research 4(3): 241–246.

Ngondi, J.L., Makamto, S.C., Etame, S.L. & Oben, J., 2006. Effect of Triumphetta cordifolia on body weight and blood lipids in normolipidemic guinea pigs. Drug Development Research 66(3): 200–203.

Nho, J.-W., Hwang, I.-G., Kim, H.-Y., Lee, Y.-R., Woo, K.-S., Hwang, B.-Y., Chang, S.-J., Lee, J. S. & Jeong, H.-S., 2010. Free radical scavenging, angiotensin I-converting enzyme (ACE) inhibitory, and in vitro anticancer activities of ramie (Boehmeria nivea) leaves extracts. Food Science and Biotechnology 19(2): 383–390.

Nia, R., Paper, D.H., Franz, G., Essien, E.E., Muganza, M. & Hohmann, G., 2005. Anti-oxidant and anti-inflammatory activity of Manniophyton fulvum. Acta Horticulturae 678: 97–101.

Nichols, G., 2005. Growing rare plants: a practical handbook on propagating the threatened plants of southern Africa. Southern African Botanical Diversity Network Report No 36. SABONET, Pretoria, South Africa. 175 pp.

Nicolle, D., 2006. A classification and census of regenerative strategies in the eucalypts (Angophora, Corymbia and Eucalyptus – Myrtaceae), with special reference to the obligate seeders. Australian Journal of Botany 54(4): 391–407.

Nicolson, D.H., Suresh, C.R. & Manilal, K.S., 1988. An interpretation of Van Rheede's Hortus Malabaricus. Koeltz, Königstein, Germany. 378 pp.

Nikiema, A., 2005. Agroforestry parkland species diversity: Uses and management in semi-arid West Africa (Burkina Faso). PhD thesis, Wageningen University, Wageningen, Netherlands. 102 pp.

Nimenibo-Uadia, R., 2003. Ficus exasperata: effects on diabetes mellitus in an experimental rat model. Global Journal of Pure and Applied Sciences 9(4): 529–532.

Nishihara, T., 1995. Feeding ecology of western lowland gorillas in the Nouabalé-Ndoki National Park, Congo. Primates 36(2): 151–168.

Nishimura, N., Izumi, A. & Kuroda, K., 2002. Structural properties of kenaf lignin: differences among kenaf varieties. Indian Crop Production 15: 115–122.

Niyomdham, C., 1997. Crotalaria spectabilis Roth. In: Faridah Hanum, I. & van der Maesen, L.J.G. (Editors). Plant Resources of South-East Asia No 11. Auxiliary plants. Backhuys Publishers, Leiden, Netherlands. pp. 105–107.

Nkeoua, G. & Boundzanga, G.C., 1999. Données sur les produits forestières non ligneux en République du Congo. FAO, Brazzaville, Congo. 125 pp.

Nnamani, C.V. & Agwu, C.O.C., 2007. Pollen analysis of honey samples from 13 local government areas of Ebonyi State, Nigeria. Bio-Research 5(1): 184–188.

Nordal, I. & Zimudzi, C., 2001. Hypoxidaceae. In: Pope, G.V. (Editor). Flora Zambesiaca. Volume 12, part 3. Royal Botanic Gardens, Kew, Richmond, United Kingdom. pp. 1–18.

Norman, A.G., 1937. The composition of some less common vegetable fibres. Biochemical Journal 31: 1575–1578.

Norman, J.C., 1992. Tropical vegetable crops. Arthur Stockwell, Elms Court, United Kingdom. 252 pp.

Normand, D., 1950. Atlas des bois de la Côte d'Ivoire. Tome 1. Centre Technique Forestier Tropical, Nogent-sur-Marne, France. 148 pp.

Normand, D., 1960. Atlas des bois de la Côte d'Ivoire. Tome 3. Centre Technique Forestier Tropical, Nogent-sur-Marne, France. 182 pp.

Normand, D. & Paquis, J., 1976. Manuel d'identification des bois commerciaux. Tome 2. Afrique guinéo-congolaise. Centre Technique Forestier Tropical, Nogent-sur-Marne, France. 335 pp.

Noumi, E., 2004. Animal and plant poisons and their antidotes in Eseka and Mbalmayo regions, Centre Province, Cameroon. Journal of Ethnopharmacology 93: 231–241.

Noumi, E., Houngue, F. & Lontsi, D., 1999. Traditional medicines in primary health care: plants used for the treatment of hypertension in Bafia, Cameroon. Fitoterapia 70: 134–139.

Nout, M.J.R., Martoyuwono, T.D., Bonné, P.C.J. & Odamtten, G.T., 1992. Hibiscus leaves for the manufacture of usar, a traditional inoculum for tempe. Journal of the Science of Food and Agriculture 58(3): 339–346.

Nsiku, E., 2003. The use of fishers' knowledge in the management of fish resources in Malawi. In: Haggan, N., Brignall, C. & Wood, L. (Editors). Putting fishers' knowledge to work. Conference

Proceedings, August 27–30, 2001. Fisheries Centre Research Report 11(1). Fisheries Centre, University of British Columbia, Canada. pp. 148–162.

Ntépé-Nyame, C., 1988. Araceae. Flore du Cameroun. Volume 31. Muséum National d'Histoire Naturelle, Paris, France. 140 pp.

Nutsugah, S.K., Tsigbey, F.K., Dzomeku, I.K. & Bimpong, I.K., 2003. Survey of rice diseases and insect pests in northern Ghana. Journal of the University of Science and Technology (Ghana) 23(1): 7–15.

Nwobodo, O., Nwafia, W.C., Ezeigbo, J.C. & Onwughalu, J., 1996. The post-coital contraceptive activity of Sida linifolia. Fitoterapia 67: 291–293.

Nyakabwa, M. & Dibaluka, M., 1990. Plantes médicinales cultivées dans la zone de Kabondo à Kisangani (Zaire). African Study Monographs 11(2): 87–99.

Nyakabwa, M., Bola, M. & Vasolene, K., 1990. Plantes sauvages alimentaires chez les Kumu de Masako à Kisangani (Zaïre). African Study Monographs 11(2): 75–86.

Nyakang'o, J.B. & van Bruggen, J.J.A., 1999. Combination of a well-functioning constructed wetland with a pleasing landscape design in Nairobi, Kenya. Water Science and Technology 40(3): 249–256.

Nyananyo, B.L., 1988. Taxonomy of the endemic African genus Clappertonia Meisner (Tiliaceae). Feddes Repertorium 99(7–8): 267–271.

Nyanayo, B.L., 1986. Pollen morphology and its taxonomic significance in the West African Medusandraceae (Rosidae). Journal of Plant Science Research 2(1): 125–128.

Nyerges, A.E., 1989. Coppice swidden fallows in tropical deciduous forest: Biological, technological, and sociocultural determinants of secondary forest successions. Human Ecology 17(4): 379–400.

Nyoka, B.I., 2003. State of forest genetic resources in Dry Zone Southern Africa Development Community countries. Forest Genetic Resources Working Paper No 41. FAO, Rome, Italy. 30 pp.

Nzigidahera, B., 2007. Ressources biologiques sauvages du Burundi : état des connaissances traditionnelles. Institut National pour l'Environnement et la Conservation de la Nature (INECN), Bujumbura, Burundi. 115 pp.

O'Shea, B.J., 2003. Checklist of the mosses of sub-Saharan Africa (version 4, 12/03). [Internet] Tropical Bryology Research Reports 4: 1–182. <http://www.oshea.demon.co.uk/ tbr/afrchk4.pdf>. Accessed 2010.

Oben, J.E., Ngondi, J.L., Momo, C.N., Agbor, G.A. & Sobgui, C.S.M., 2008. The use of a Cissus quadrangularis/Irvingia gabonensis combination in the management of weight loss: a double-blind placebo-controlled study. [Internet] Lipids in Health and Disease 7: 12. <http://www.lipidworld.com/ content/7/1/12>. Accessed February 2011.

Obermeyer, A.A., 1985. Juncaceae. In: Leistner, O.A. (Editor). Flora of southern Africa. Volume 4, part 2. Botanical Research Institute, Department of Agriculture and Water Supply, Pretoria, South Africa. pp. 71–91.

Obermeyer, A.A., 1992. Sansevieria. In: Leistner, O.A. (Editor). Flora of southern Africa. Volume 5, part 3. National Botanical Institute, Pretoria, South Africa. pp. 5–9.

Oboh, I.O. & Aluyor, E.O., 2009. Luffa cylindrica – an emerging cash crop. African Journal of Agricultural Research 4(8): 684–688.

Obuotor, E.M. & Onajobi, F.D., 2000. Preliminary evaluation of cytotoxic properties of Raphia hookeri fruit mesocarp. Fitoterapia 71(2): 190–192.

Odoi, F.N.A., Awuah-Kyei, E., Laryea, T.T. & Wumbei, I.M., 2002. A survey of indigenous browse species used as feed for small ruminants in the Atwima district of the Ashanti region of Ghana. Journal of the Ghana Science Association 4(2): 6.

Ofori, J., 2008. Mechanical strength properties of Broussonetia papyrifera from Afram Headwaters Forest Reserve in Ghana. Research results presented at a colloquium held on 28th August 2008 at FORIG, Kumasi, Ghana.

Ogbuagu, M.N, 2008. Vitamins, phytochemicals and toxic elements in the pulp and seed of raphia palm fruit (Raphia hookeri). Fruits 63(5): 297–302.

Ogunkunle, A.T.J., 2010. A quantitative modelling of pulp and paper making suitability of Nigerian hardwood species. Advances in Natural and Applied Sciences 4(1): 14–21.

Oh, T.J. & Cullis, C.A., 2003. Labile DNA sequences in flax identified by combined sample representational difference analysis (CSRDA). Plant Molecular Biology 52: 527–536.

Ohigashi, H., Takagaki, T., Koshimizu, K., Watanabe, K., Kaji, M., Hoshino, J., Nishida, T., Huffman, M.A., Takasaki, H., Jato, J. & Muanza, D.N., 1991. Biological activities of plant extracts from tropical Africa. African Study Monographs 12(4): 201–210.

Ohiri, F.C., Verpoorte, R. & Baerheim Svendsen, A., 1983. The African Strychnos species and their alkaloids: a review. Journal of Ethnopharmacology 9(2–3): 167–223.

Ohrnberger, D., 1999. The bamboos of the World. Elsevier, Amsterdam. 585 pp.

Ohtani, K., Okai, K., Yamashita, U., Yuasa, I. & Misaki, A., 1995. Characterization of an acidic polysaccharide isolated from the leaves of Corchorus olitorius (Moroheiya). Bioscience, Biotechnology, and Biochemistry 59: 378–381.

Ohwoavworhua, F.O. & Adelakun, T.A., 2005. Some physical characteristics of microcrystalline cellulose obtained from raw cotton of Cochlospermum planchonii. Tropical Journal of Pharmaceutical Research 4(2): 501–507.

Okeyo, J.M., 2006. Erythrophleum suaveolens (Guill. & Perr.) Brenan. [Internet] Record from Protabase. Schmelzer, G.H. & Gurib-Fakim, A. (Editors). PROTA (Plant Resources of Tropical Africa / Ressources végétales de l'Afrique tropicale), Wageningen, Netherlands. <http://database.prota.org/search.htm>. Accessed June 2011.

Okokon, J.E, Antia, B.S. & Umoh, E., 2008. Analgesic and anti-inflammatory effects of ethanolic root extract of Hippocratea africana. International Journal of Pharmacology 4(1): 51–55.

Okokon, J.E., Ita, B.N. & Udokpoh, A., 2006. The in-vivo antimalarial activities of Uvaria chamae and Hippocratea africana. Annals of Tropical Medicine and Parasitology 100(7): 585–590.

Okoli, B.E., 1984. Wild and cultivated cucurbits in Nigeria. Economic Botany 38(3): 350–357.

Okoli, I.C., Ebere, C.S., Uchegbu, M.C., Udah, A. & Ibeawuchi, I.I., 2003. A survey of the diversity of plants utilized for small ruminant feeding in south-eastern Nigeria. Agriculture, Ecosystems & Environment 96(1–3): 147–154.

Okurut, T.O., Rijs, G.B.J. & van Bruggen, J.J., 1999. Design and performance of experimental constructed wetlands in Uganda, planted with Cyperus papyrus and Phragmites mauritianus. Water Science and Technology 40(3): 265–271.

Okwari, O.O., Ettarh, R.R., Akpogomeh, B.A. & Eteng, M.U., 2000. Gastric anti-secretory and antiulcerogenic effects of Dombeya buettneri in rats. Journal of Ethnopharmacology 71(1–2): 315–219.

Oladokun, M.A.O., 1990. Tree crop based agroforestry in Nigeria: a checklist of crops intercropped with cocoa. Agroforestry Systems 11(3): 227–241.

Olafsdottir, E.S., Andersen, J.V. & Jaroszewski, J.W., 1989. Cyanohydrin glycosides of Passifloraceae. Phytochemistry 28(1): 127–132.

Oliver, E.G.H., 1987. Studies in the Ericoideae (Ericaceae) VII. The placing of the genus Philippia into synonymy under Erica; the Southern African species. South African Journal of Botany 53(6): 455–458.

Oliver, E.G.H., 1992. Studies in the Ericoideae (Ericaceae). VIII. New combinations for Philippia are made in Erica for the Flora Zambesiaca region. Kew Bulletin 47(4): 665–668.

Oliver-Bever, B., 1986. Medicinal plants in tropical West Africa. Cambridge University Press, Cambridge, United Kingdom. 375 pp.

Olorunnisola, A.O., 2004. Briquetting of rattan furniture waste. Journal of Bamboo and Rattan 3(2): 139–149.

Olorunnisola, A.O., Pitman, A. & Mansfield-William, H., 2005. Strength properties and potential uses of rattan-cement composites. Journal of Bamboo and Rattan 4(4): 343–352.

Olotuah, O.F., 2006. Suitability of some local bast fibre plants in pulp and paper making. Journal of Biological Sciences 6(3): 635–637.

Omagor, N., 1999. Swamp forest plant resources in Uganda: their uses and conservation challenges. International Tree Crops Journal 10(2): 107–120.

Omeja, P., Obua, J. & Cunningham, A.B., 1995. Demand and supply of wood for drum making in central Uganda. International Forestry Review 7(1): 21–26, 78, 80.

Onana, J., 1995. Les ligneux fourragers du Nord-Cameroun. I. Inventaire et phénologie. Revue d'Elevage et de Médecine Vétérinaire des Pays Tropicaux 48: 213–219.

Onelli, E., Patrignani, G. & Carraro, L., 2001. Spatial arrangement of the fibres in developing and mature endocarp of Luffa cylindrica Roem. Plant Biosystems 135(1): 39–44.

Ong, H.C., 2001. Urena lobata L. In: van Valkenburg, J.L.C.H. & Bunyapraphatsara, N. (Editors). Plant Resources of South-East Asia No 12(2): Medicinal and poisonous plants 2. Backhuys Publishers, Leiden, Netherlands. pp. 575–577.

Onochie, C.F.A. & Leeuwenberg, A.J.M., 1963. Loganiaceae. In: Hepper, F.N. (Editor). Flora of West Tropical Africa. Volume 2. 2nd Edition. Crown Agents for Oversea Governments and Administrations, London, United Kingdom. pp. 34–47.

Onwuka, C.F.I., Taiwo, B.B.A. & Adu, I.F., 1992. Browse species and supplements used for feeding small ruminants in Ogun State, Nigeria.1992. In: Stares, J.E.C., Said, A.N. & Kategile, J.A. (Editors). The complementarity of feed resources for animal production in Africa. Proceedings of the joint feed resources networks workshop held in Gaborone, Botswana, 4–8 March 1991. African Feeds Research Network, Addis Ababa, Ethiopia. pp. 173–180.

Opute, F.I., 1978. Mesocarp, seed and pollen lipids of Raphia palms. Journal of the Science of Food and Agriculture 29: 115–120.

Orr, D.M., Burrows, W.H., Hendricksen, R.E., Clem, R.L., Rutherford, M.T., Conway, M.J., Myles, D.J., Back, P.V. & Paton, C.J., 2001. Pasture yield and composition changes in a Central Queensland black spear grass (Heteropogon contortus) pasture in relation to grazing management option. Australian Journal of Experimental Agriculture 41(4): 477–485.

Oruade-Dimaro, E.A., 1987. The occurrence of brown fruit rot of Raphia species in Nigeria. Nigerian Journal of Palms and Oil Seeds 8(1): 41–49.

Oruade-Dimaro, E.A. & Ekundayo, C.A., 1992. Seedling blight disease of Raphia hookeri caused by Glomerella cingulata in Nigeria. Principes 36(1): 41–44.

Orwa, C., Mutua, A., Kindt, R., Jamnadass, R. & Simons, A., 2009. Agroforestree database: a tree reference and selection guide. Version 4.0. [Internet] World Agroforestry Centre (ICRAF), Nairobi, Kenya. <http://www.worldagroforestry.org/ resources/databases/ agroforestree>. Accessed April 2010 - August 2011.

Osei, A.A., 2005. Chemical analysis of a Ghanaian rattan species (Eremospatha macrocarpa). B.Sc. Natural Resource Management degree thesis, Institute of Renewable Natural Resources, Kwame Nkrumah University of Science and Technology, Kumasi, Ghana. 38 pp.

Osemeobo, J.G., 2005. Living on wild plants: evaluation of the rural household economy in Nigeria. Environmental Practice 7: 246–256.

Osho, J. S. A., 1996. Modelling the tree population dynamics of the most abundant species in a Nigerian tropical rain forest. Ecological Modelling 89(1–3): 175–181.

OT Africa Line, 2007. West African commodity report (April 2007). OT Africa Line, Birmingham, United Kingdom. [Internet] <http://www.otal.com/ images/OTAL%20Services/CommodityReport/ Commodity%20April%202007.pdf>. Accessed April 2007.

Otchoumou, A., N'Da, K. & Kouassi, K.D., 2005. L'élevage des escargots géants comestibles d'Afrique: inventaire de végétaux sauvages consommés par Achatina achatina (Linne 1758) et préférences alimentaires. Livestock Research for Rural Development 17(3): article 28.

Otedoh, M.O., 1973. The production of piassava in Nigeria. Nigerian Agricultural Journal 10(2): 260–264.

Otedoh, M.O., 1974. Raphia oil: its extraction, properties and utilization. Journal of the Nigerian Institute for Oil Palm Research 5(19): 45–49.

Oteng-Amoako, A.A. & Ebanyenle, E., 2002. The anatomy of five economic rattan species from Ghana. In: Sunderland, T.C.H. & Profizi, J.P. (Editors). New research on African rattans. Proceedings of the CARPE-funded International Expert Meeting on the Rattans of Africa, held at the Limbe Botanic Garden, Cameroon, 1–3 February 2000. International Network for Bamboo and Rattan (INBAR), Beijing, China. pp. 17–31.

Oteng-Amoako, A.A. & Obiri-Darko, B., 2002. Rattan as a sustainable cottage industry in Ghana: the need for development interventions. In: Sunderland, T.C.H. & Profizi, J.P. (Editors). New research on African rattans. Proceedings of the CARPE-funded International Expert Meeting on the Rattans of Africa, held at the Limbe Botanic Garden, Cameroon, 1–3 February 2000. International Network for Bamboo and Rattan (INBAR), Beijing, China. pp. 105–114.

Oteng-Amoako, A.A. & Obiri-Darko, B., 2003. Rattan as a sustainable cottage industry in Ghana: the need for development interventions. In: Sunderland, T.C.H. & Profizi, J.P. (Editors). New research on African rattans. Proceedings of the CARPE-funded International Expert Meeting on the Rattans of Africa, held at the Limbe Botanic Garden, Cameroon, 1–3 February 2000. International Network for Bamboo and Rattan (INBAR), Beijing, China. pp. 17–32.

Oteng-Amoako, A.A. (Editor), 2006. 100 tropical African timber trees from Ghana: tree description and wood identification with notes on distribution, ecology, silviculture, ethnobotany and wood uses. 304 pp.

Otieno, J.N., Lyaruu, H.V.M. & Hosea, K.M.M., 2007. Effect of domestication on bioactivity of medicinal herbs: case of Tarime District, Tanzania. Discovery and Innovation 19: S85–S91.

Otoo, M., 2001. Vegetative propagation of rattans (Ancistrophyllum opacum, Calamus deeratus and Eremospatha macrocarpa). B.Sc. Natural Resource Management degree thesis, Institute of Renewable Natural Resources, Kwame Nkrumah University of Science and Technology, Kumasi, Ghana. 46 pp.

Ouedraogo, L., 2008. Raphia palma-pinus. In: IUCN. 2010 Red list of threatened species. Version 2010.4. [Internet] <http://www.iucnredlist.org>. Accessed January 2011.

Owen, A. & Danzing, R., 1993. The history and treatment of the papyrus collection at the Brooklyn Museum. [Internet] The Book and Paper Group Annual 12. <http://aic.stanford.edu/sg/bpg/annual/v12/bp12–10.html>. Accessed May 2009.

Owino, A.O. & Ryan, P.G., 2007. Recent papyrus swamp habitat loss and conservation implications in western Kenya. Wetlands Ecology and Management 15:1–12.

Owusu, F.W., 2008. Sawing & machining properties of Broussonetia papyrifera from Afram Headwaters Forest Reserve in Ghana and development of some prototype products. Research findings presented at a colloquium held on 28th August 2008 at FORIG, Kumasi, Ghana.

Owusu-Dapaah, G., 1993. Isolation, identification and some chemical and biological studies on the compound funiferine from Tilacora funifera (Memispermaceae). M. (Pharm) degree thesis, Department of Pharmaceutical Chemistry, Faculty of Pharmacy, Kwame Nkrumah University of Science and Technology, Kumasi, Ghana. 164 pp.

Owusu-Sekyere, E., 1999. Some indigenous trees for agroforestry in the derived savannah zone of Ghana. Ghana Journal of Forestry 8: 53–58.

Owusu-Yeboah, P., 1993. Socio-economic study of Marantaceae leaf gathering in Asuboi – case study. B.Sc. Natural Resource Management degree thesis, Institute of Renewable Natural Resources, Kwame Nkrumah University of Science and Technology, Kumasi, Ghana. 76 pp.

Oyedeji, A.O., Ekundayo, O., Olawore, O.N., Adeniyi, B.A. & Koenig, W.A., 1999a. Antimicrobial activity of the essential oils of five Eucalyptus species growing in Nigeria. Fitoterapia 70(5): 526–528.

Oyedeji, A.O., Olawore, O.N., Ekundayo, O. & Koenig, W.A., 1999b. Volatile leaf oil constituents of three Eucalyptus species from Nigeria. Flavour and Fragrance Journal 14(4): 241–244.

Oyen, L.P.A., 2003. Phragmites vallatoria (Pluk. ex L.) J.F. Veldkamp. In: Brink, M. & Escobin, R.P. (Editors). Plant Resources of South-East Asia No 17. Fibre plants. Backhuys Publishers, Leiden, the Netherlands. pp. 209–211.

Oyetayo, F.L., Oyetayo, V.O. & Ajewole, V., 2007. Phytochemical profile and antibacterial properties of the seed and leaf of the Luffa plant (Luffa cylindrica). Journal of Pharmacology and Toxicology 2(6): 586–589.

Oyugi, J.O., Brown, J.S. & Whelan, C.J., 2008. Effects of human disturbance on composition and structure of Brachystegia woodland in Arabuko-Sokoke Forest, Kenya. African Journal of Ecology 46(3): 374–383.

Ozenda, P., 1977. Flore du Sahara. Deuxième édition. Centre National de la Recherche Scientifique, Paris, France. 622 pp.

Ozolua, R.I., Alonge, P. & Igbe, I., 2009. Effects of leaf extracts of Piliostigma thonningii Schum. on aortic ring contractility and bleeding time in rats. Journal of Herbs, Spices & Medicinal Plants 15(4): 326–333.

Paiva, J.A.R., 1998. Polygalarum africanarum et madagascariensium prodromus atque gerontogæi generis Heterosamara Kuntze, a genere Polygala L. segregati et a nobis denuo recepti, synopsis monographica. Fontqueria 50: 1–356.

Paiva, J., 2007. Polygalaceae. In: Beentje, H.J. & Ghazanfar, S.A. (Editors). Flora of Tropical East Africa. Royal Botanic Gardens, Kew, Richmond, United Kingdom. 61 pp.

Pakia, M. & Cooke, J.A., 2003a. The ethnobotany of the Midzichenda tribes of the coastal forest areas in Kenya: 1. General perspective and non-medicinal plant uses. South African Journal of Botany 69(3): 370–381.

Pakia, M. & Cooke, J.A., 2003b. The ethnobotany of the Midzichenda tribes of the coastal forest areas in Kenya: 2. Medicinal plant uses. South African Journal of Botany 69(3): 382–395.

Pal, B.P., Singh, H.B. & Swarup, V., 1952. Taxonomic relationships and breeding possibilities of species of Abelmoschus related to okra (A. esculentus). Botanical Gazette 113(4): 455–464.

Palaniappan, V.M., 1974. Ecology of tin tailings areas: plant communities and their succession. Journal of Applied Ecology 11: 133–150.

Palmer, E. & Pitman, N., 1972–1974. Trees of southern Africa, covering all known indigenous species in the Republic of South Africa, South-West Africa, Botswana, Lesotho and Swaziland. 3 volumes. Balkema, Cape Town, South Africa. 2235 pp.

Palve, S.M. & Sinha, M.K., 2005. Genetic variation and interrelationships among fibre yield attributes in secondary gene pool of Corchorus spp. SABRAO Journal of Breeding and Genetics 37(1): 55–64.

Palve, S.M., Sinha, M.K. & Mandal, R.K., 2004. Sources of stem rot [Macrophomina phaseolina (Tassi) Goid.] resistance in wild species of jute. Tropical Agriculture 81(1): 23–27.

Panda, K.K., Panigrahy, R.K., Das, A.B. & Panda, B.B., 2007. Analyses of chromosome number, nuclear DNA content and RAPD profile in three morphotypes of Pandanus fascicularis Lam. Plant Genetic Resources Newsletter 152: 12–22.

Pandey, S.N. & Suri, L.K., 1982. Cyclo propenoid fatty-acid content and iodine value of crude oils from Indian cottonseed. Journal of the American Oil Chemists' Society 59(2): 99–101.

Panichev, N., Mabasa, W., Ngobeni, P., Mandiwana, K. & Panicheva, S., 2008. The oxidation of Cr(3) to Cr(6) in the environment by atmospheric oxygen during the bush fires. Journal of Hazardous Materials 153(3): 937–941.

Panthonga, A., Supraditaporna, W., Kanjanapothia, D., Taesotikula, T. & Reutrakulb, V., 2007. Analgesic, anti-inflammatory and venotonic effects of Cissus quadrangularis Linn. Journal of Ethnopharmacology 110(2): 264–270.

Pare, S., Savadogo, P., Tigabu, M., Ouadba, J.M. & Oden, P.C., 2010. Consumptive values and local perception of dry forest decline in Burkina Faso, West Africa. Environment, Development and Sustainability 12(2): 277–295.

Parmar, N.S. & Ghosh, M.N., 1978. Anti-inflammatory activity of gossypin of bioflavonoid isolated from Hibiscus vitifolius Linn. Indian Journal of Pharmacology 10(4): 277–293.

Parmentier, I., 2003. Study of the vegetation composition in three inselbergs from continental Equatorial Guinea (western Central Africa): effects of site, soil factors and position relative to forest fringe. Belgian Journal of Botany 136(1): 63–72.

Parmentier, I. & Müller, J.V., 2006. Grasslands and herbaceous fringes on inselbergs in Atlantic Central Africa. Phytocoenologia 36(4): 565–597.

Pascal, O., 2002. Plantes et forêts de Mayotte. Patrimoines Naturels 53. 108 pp.

Paswan, V.K., Mahapatra, R.K., Meena, H.R. & Sahoo, A., 2008. Nutrient Composition and Phenolic Constituents in some Feed and Fodder Samples from Temperate Regions of Kumaon Himalaya. Indian Journal of Animal Nutrition 25: 19–24.

Patel, A., 1996. Variation in a mutualism: phenology and the maintenance of gynodioecy in two Indian fig species. Journal of Ecology 84(5): 667–680.

Patel, K.V., Varghese, S., Patel, P.G. & Patel, U.G., 2002. Oil and fatty acid profile of different varieties of Gossypium species. Journal of Maharashtra Agricultural Universities 27(3); 315–316.

Pauwels, L., 2002. Inventaire d'herbiers (Afrique - R.D. Congo). [Internet] <http://www.nzenzeflowerspauwels.be/ HERBKIN.htm>. Accessed September 2009.

Payne, T.J., 2000. Promoting better health with flaxseed in bread. Cereal Foods World 45: 102–104.

Peeler, C.H., 1967. Production of kenaf and other soft fibres in Kenya. East African Agricultural and Forestry Journal 33(2): 139–144.

Peeters, M.-C., van Langenhove, L., Louwagie, J., Waterkeyn, L. & Mergeai, G., 2001. Cotton. In: Raemaekers, R.H. (Editor). Crop production in tropical Africa. DGIC (Directorate General for International Cooperation), Ministry of Foreign Affairs, External Trade and International Cooperation, Brussels, Belgium. pp. 1041–1070.

Pelter, A., Amenechi, P.I., Warren, R. & Harper, S.H., 1969. The structures of two proanthocyanidins from Julbernardia globiflora. Journal of the Chemical Society, Section C, Organic chemistry 1969(19): 2572–2579.

Penfold, A.R. & Willis, J.L., 1961. The eucalypts: botany, cultivation, chemistry and utilization. Leonard Hill, London, United Kingdom & Interscience Publishers, New York, United States. 550 pp.

Percy, R.G., 2009. The worldwide gene pool of Gossypium barbadense L. and its improvement. In: Paterson, A.H. (Editor). Genetics and genomics of cotton. Springer-Verlag New York, United States. pp. 53–68.

Percy, R.G., Calhoun, M.C. & Kim, H.L., 1996. Seed gossypol variation within Gossypium barbadense L. cotton. Crop Science 36(1): 193–197.

Pereira, T., Shackleton, C. & Shackleton, S., 2006. Trade in reed-based craft products in rural villages in the Eastern Cape, South Africa. Development Southern Africa 23(4): 477–495.

Pérez, S.A., Renedo, C.J., Oretiz, A. & Mañana, M., 2008. Energy potential of waste from 10 forest species in the North of Spain (Cantabria). Bioresource Technology 99(14): 6339–6345.

Perrier de la Bâthie, H., 1945. Passifloracées (Passifloraceae). Flore de Madagascar et des Comores (plantes vasculaires), famille 143. Imprimerie Officielle, Tananarive, Madagascar. 50 pp.

Perrier de la Bâthie, H., 1946. Juncacées (Juncaceae). Flore de Madagascar et des Comores (plantes vasculaires), familles 38–39. Imprimerie Officielle, Tananarive, Madagascar. 5 pp.

Perrier de la Bâthie, H., 1950. Velloziacées (Velloziaceae). Flore de Madagascar et des Comores (plantes vasculaires), familles 41–43. Firmin-Didot et cie., Paris, France. 17 pp.

Perrier de la Bâthie, H., 1952. Linacées (Linaceae). Flore de Madagascar et des Comores (plantes vasculaires), familles 101–103. Firmin-Didot et cie., Paris, France. 17 pp.

Perrier de la Bâthie, H. & Leandri, J., 1952. Moracées (Moraceae). Flore de Madagascar et des Comores (plantes vasculaires), famille 55. Firmin-Didot et cie., Paris, France. 76 pp.

Perrotta, D.M., Coody, G. & Culmo, C., 1996. Adverse events associated with ephedrine-containing products. Morbidity and Mortality Weekly 45(32): 689–691.

Persad, C. & Fortune, M., 1989. A new disease of sorrel (Hibiscus sabdariffa var. sabdariffa) caused by Coniella musaiaensis var. hibisci from Trinidad and Tobago. Plant Pathology 38: 615–617.

Persoon, J.G.M., van Dilst, F.J.H., Kuijpers, R.P., Leeuwenberg, A.J.M. & Vonk, G.J.A., 1992. The African species of Landolphia P. Beauv. Series of revisions of Apocynaceae 34. Wageningen Agricultural University Papers No 92–2. Wageningen Agricultural University, Wageningen, Netherlands. 232 pp.

Peters, C.R., 1994. African wild plants with rootstocks reported to be eaten raw: the monocotyledons, part 3. In: Seyani, J.H. & Chikuni, A.C. (Editors). Proceedings of the 13th Plenary Meeting of AETFAT, Zomba, Malawi, 2–11 April 1991. National Herbarium and Botanic Gardens of Malawi, Zomba, Malawi. pp. 25–38.

Peters, C.R., O'Brien, E.M. & Drummond, R.B., 1992. Edible wild plants of sub-saharan Africa. Royal Botanic Gardens, Kew, Richmond, United Kingdom. 239 pp.

Peterson, B., 1976. A new species of Gnidia (Thymelaeaceae) from Mlanje and Namuli mountains. Kew Bulletin 31(1): 177–179.

Peterson, B., 1978. Thymelaeaceae. In: Polhill, R.M. (Editor). Flora of Tropical East Africa. Crown Agents for Oversea Governments and Administrations, London, United Kingdom. 37 pp.

Peterson, B., 2000. Thymelaeaceae. In: Edwards, S., Mesfin Tadesse, Demissew Sebsebe & Hedberg, I. (Editors). Flora of Ethiopia and Eritrea. Volume 2, part 1. Magnoliaceae to Flacourtiaceae. The National Herbarium, Addis Ababa University, Addis Ababa, Ethiopia and Department of Systematic Botany, Uppsala University, Uppsala, Sweden. pp. 429–435.

Peterson, B., 2006. Thymelaeaceae. In: Pope, G.V., Polhill, R.M. & Martins, E.S. (Editors). Flora Zambesiaca. Volume 9, part 3. Royal Botanic Gardens, Kew, Richmond, United Kingdom. pp. 85–117.

Petit, E., 1958. Polygalaceae. In: Robyns, W., Staner, P., Demaret, F., Germain, R., Gilbert, G., Hauman, L., Homès, M., Jurion, F., Lebrun, J., Vanden Abeele, M. & Boutique, R. (Editors). Flore du Congo belge et du Ruanda-Urundi. Spermatophytes. Volume 7. Institut National pour l'Étude Agronomique du Congo belge, Brussels, Belgium. pp. 238–286.

Pettit, G.R., Zhang, Q., Pinilla, V., Hoffmann, H., Knight, J.C., Doubek, D.L., Chapuis, J.C., Pettit, R.K. & Schmidt, J.M., 2005. Antineoplastic agents. 534. Isolation and structure of Sansevistatins 1 and 2 from the African Sansevieria ehrenbergii. Journal of Natural Products 68(5): 729–733.

Peyre de Fabrègues, B. & Lebrun, J.-P., 1976. Catalogue des plantes vasculaires du Niger. Etude Botanique 3. Institut d'Elèvage et de Médecine Vétérinaire des Pays Tropicaux. Paris, France. 433 pp.

PFAF, 1996–2008. Plants for a future database. [Internet] Plants for a future (PFAF) foundation, Lerryn, Lostwithiel, United Kingdom. <http://www.pfaf.org/ database/ index.php>. Accessed April 2009.

Phillips, C., 1993. Longicorn beetles 1. Forest Health Information Fact Sheets No 17. PIRSA Forestry, Mount Gambier, Australia. 3 pp.

Phillips, C., 1994. Chrysomelid beetles – Chrysophtharta spp. and Paropsis spp. Forest Health Information Fact Sheets No 21. PIRSA Forestry, Mount Gambier, Australia. 6 pp.

Phillips, S., 1995. Poaceae (Gramineae). In: Hedberg, I. & Edwards, S. (Editors). Flora of Ethiopia and Eritrea. Volume 7. Poaceae (Gramineae). The National Herbarium, Addis Ababa University, Addis Ababa, Ethiopia and Department of Systematic Botany, Uppsala University, Uppsala, Sweden. 420 pp.

Phillipson, P.B., 2004. Xerophyta. A Catalogue of the Vascular Plants of Madagascar. [Internet] <http://www.efloras.org/ florataxon.aspx?flora_id=12&taxon_id=135105>. Accessed February 2009.

Phiri, P.S.M., 1998. Brachystegia bakeriana. In: IUCN. Red list of threatened species. Version 2010.1. [Internet] <http://www.iucnredlist.org>. Accessed April 2010.

Piatek, M., 2006. Urocystis skirgielloi, a new graminicolus smut fungus infecting Heteropogon contortus in India. Acta Mycologica 41(1): 7–10.

Pichon, M., 1953. Monographie des Landolphiées : classification des Apocynacées. Mémoires de l'Institut Français d'Afrique Noire No 35. Institut Français d'Afrique Noire, Dakar, Senegal. 437 pp.

Pichon, M., 1954. Révision du genre Alafia Thou. Bulletin du Jardin Botanique de l'État (Bruxelles) 24: 129–222.

Pienaar, K., 2003. Gardening with indigenous plants. Struik Publishers, Cape Town, South Africa. 96 pp.

Piha, M.I., Vallack, H.W., Michael, N. & Reeler, B.M., 1995. A low input approach to vegetation establishment on mine and coal ash wastes in semi-arid regions. II. Lagooned pulverized fuel ash in Zimbabwe. Journal of Applied Ecology 32(2): 382–390.

Pill, W.G., Tilmon, H.D. & Taylor, R.W., 1995. Nitrogen enriched ground kenaf (Hibiscus cannabinus L.) stem core as a component of soilless growth media. Journal of Horticultural Science 70(4): 673–681.

Pilonchéry, A., 1999. L'île de la Réunion et la culture de la vanille. Bulletin mensuel de la Société linnéenne de Lyon 68(5): 96–99.

Pinto Basto, M.F., 2002. Urticaceae. In: Martins, E.S., Diniz, M.A., Paiva, J., Gomes, I. & Gomes, S. (Editors). Flora de Cabo Verde: Plantas vasculares. No 8. Instituto de Investigação Científica Tropical, Lisbon, Portugal & Instituto Nacional de Investigação e Desenvolvimento Agrário, Praia, Cape Verde. 16 pp.

Pischtschan, E., Ley, A.C. & Claβen-Bockhoff, R., 2010. Ontogenetic and phylogenetic diversification of the hooded staminode in Marantaceae. Taxon 59(4): 1111–1125.

Poilecot, P., 1995. Les Poaceae de Côte d'Ivoire. Manuel illustré d'identification des espèces. Boissera 50: 1–734.

Poilecot, P., 1999. Les Poaceae du Niger, description, illustration, ecologie, utilisations. Boissiera 56: 1–766.

Polhill, R.M., 1982. Crotalaria in Africa and Madagascar. A.A. Balkema, Rotterdam, Netherlands. 389 pp.

Polomski, R.F., Bielenberg, D.G., Whitwell, T., Taylor, M.D., Bridges, W.C. & Klaine, S.J., 2008. Differential nitrogen and phosphorus recovery by five aquatic garden species in laboratory-scale subsurface-constructed wetlands. HortScience 43(3): 868–874.

Poncy, O., 1978. Le genre Pararistolochia, Aristolochiaceae d'Afrique tropicale. Adansonia sér. 2, 17: 465–494.

Ponzio, K.J., Miller, S.J. & Lee, M.A., 1995. Germination of sawgrass, Cladium jamaicense Crantz, under varying hydrologic conditions. Aquatic Botany 51(1–2): 115–120.

Poonawala, I.S., Jana, M.M. & Nadgauda, R.S., 1999. Factors influencing bud break and rooting and mass scale micropropagation of three Phragmites species: P. karka, P. communis and P. australis. Plant Cell Reports 18(7–8): 696–700.

Poorter, L., Bongers, F., Kouamé, F.Y.N. & Hawthorne, W.D., 2004. Biodiversity of West African forests: an ecological atlas of woody plant species. CABI, Wallingford, United Kingdom. 521 pp.

Poppendieck, H.H., 1980. A monograph of the Cochlospermaceae. Botanische Jahrbücher für Systematik, Pflanzengeschichte und Pflanzengeographie 101: 191–265.

Porembski, S., 2003. Epiphytic orchids on arborescent Velloziaceae and Cyperaceae: extremes of phorophyte specialisation. Nordic Journal of Botany 23(4): 505–512.

Porembski, S., Brown, G. & Barthlott, W., 1996. A species-poor tropical sedge community: Afrotrilepis pilosa mats on inselbergs in West Africa. Nordic Journal of Botany 16(3): 239–245.

Portères, R., 1950. Vieilles agricultures de l'Afrique intertropicale: Centres d'origine et de diversification variétale primaire et berceaux d'agriculture antérieurs au XVIe siècle. Agronomie Tropicale 5: 489–507.

Portères, R., 1974. Un curieux élément culturel Arabico-Islamique et Néo-Africain : les baguettes végétales machées servant de frotte-dents. Journal d'Agriculture Tropicale et de Botanique Appliquée 21(4–6) : 1–36; 111–149.

Porterfield, W.M. Jr., 1955. Loofah – the sponge gourd. Economic Botany 9: 211–223.

Poullain, C., Girard-Valenciennes, E. & Smadja, J., 2004. Plants from Reunion island: evaluation of their free radical scavenging and antioxidant activities. Journal of Ethnopharmacology 95: 19–26.

Powell, R.G., Bajaj, R. & McLaughlin, J.L., 1987. Bioactive stilbenes of Scirpus maritimus. Journal of Natural products 50(2): 293–296.

Prajapati, N.S., Purohit, S.S., Sharma, A.K. & Kumar, T., 2003. A handbook of medicinal plants: a complete source book. Agrobios, Jodhpur, India. 554 pp. + Annexes.

Prakash, D., Jain, R.K. & Misra, P.S., 1988. Amino acid profiles of some under-utilised seeds. Plant Foods for Human Nutrition 38: 235–241.

Praptosuwiryo, T.N., 2003. Sansevieria Thunb. In: Brink, M. & Escobin, R.P. (Editors). Plant Resources of South-East Asia No 7. Fibre plants. Backhuys Publishers, Leiden, Netherlands. pp. 217–221.

Pratt, J.H., Henry, E.M.T., Mbeza, H.F., Mlaka E. & Satali, L.B., 2002. Malawi Agroforestry Extension Project Marketing & Enterprise Program. Main Report. Publication No. 47. Malawi Agroforestry Extension Project (MAFE), Lilongwe, Malawi. 119 pp.

Prince, L.M. & Kress, J., 2006a. Phylogenetic relationships and classification in Marantaceae: insights from plastid DNA sequence data. Taxon 55(2): 281–296.

Prince, L.M. & Kress, J., 2006b. Phylogeny and biogeography of the prayer plant family: getting to the root problem in Marantaceae. Aliso 22: 645–659.

Profizi, J.P., 1986a. Biologie et mode de gestion des marécages à Raphia hookeri Mann & Wendland au sud-est du Bénin. Journal d'Agriculture Traditionnelle et de Botanique Appliquée 33: 49–58.

Profizi, J.P., 1986b. Notes on West African rattans. RIC Bulletin 5(1): 1–3.

Profizi, J.-P., 1988. Swampy area transformations by exploitation of Raphia hookeri (Arecaceae) in southern Benin (West Africa). Human Ecology 16(1): 87–94.

Profizi, J.-P., 1999. The management of forest resources by local people and the state in Gabon. In: Sunderland, T.C.H., Clark, L.E. & Vantomme, P. (Editors). Non-wood forest products of Central Africa: current research issues and prospects for conservation and development. Food and Agriculture Organisation, Rome, Italy. pp. 133–138.

Purseglove, J.W., 1968. Tropical Crops. Dicotyledons. Longman, London, United Kingdom. 719 pp.

Purseglove, J.W., 1972. Tropical crops. Monocotyledons. Volume 2. Longman, London, United Kingdom. 273 pp.

Pyykkö, M., 1985. Anatomy of the stem and petiole of Raphia hookeri (Palmae). Annales Botanici Fennici 22: 129–138.

Quadri-Spinelli, T., 1970. Biological screening of medicinal plants from Papua New Guinea and phytochemical investigation of the fern Cyclosorus interruptus. PhD thesis, Swiss Federal Institute of Technology, Zürich, Switzerland.

Quadri-Spinelli, T., Heilmann, J., Rali, T. & Sticher, O., 2000. Bioactive coumarin derivatives from the fern Cyclosorus interruptus. Planta Medica 66(8): 728–733.

Quarcoo, B., 1996. Effect of fertilizer top dressing on the height growth of two rattan species (Calamus deerratus; Eremospatha macrocarpa) at planting. B.Sc. Natural Resource Management degree thesis, Institute of R3newable Natural Resources, Kwame Nkrumah University of Science and Technology, Kumasi, Ghana. 45 pp.

Quattrocchi, U., 2006. CRC world dictionary of grasses: common names, scientific names, eponyms, synonyms, and etymology. 3 volumes. CRC, Taylor & Francis, Boca Raton, Florida, United States. 2383 pp.

Quénéhervé, P., Chabrier, C., Auwerkerken, A., Topart, P., Martiny, B. & Marie-Luce, S., 2006. Status of weeds as reservoirs of plant parasitic nematodes in banana fields in Martinique. Crop Protection 25(8): 860–867.

Rabarimanarivo, M., Jeannoda, V. & Rabakonandrianina, E., 2005. Etude des plantes artisanales de marécage du sud-est de Madagascar: etude écologique et socio-économique. Tohiravina 1: 30–37.

Rabe, T. & van Staden, J., 1997. Antibacterial activity of South African plants used for medicinal purposes. Journal of Ethnopharmacology 56: 81–87.

Rabemanantsoa, H.F., Roger, E. & Jeannoda, V., 2007. Etude écologique de la végétation du site Enjoy Sakatia: écologie, flore et végétation pour contribuer à sa restauration écologique. Tohiravina 2: 305–313.

Radcliffe-Smith, A., 1989. Notes on African Euphorbiaceae: 20. Acalypha (ii), etc. Kew Bulletin 44(3): 439–454.

Radcliffe-Smith, A., 1996. Euphorbiaceae, subfamilies Phyllantoideae, Oldfieldioideae, Acalyphoideae, Crotonoideae and Euphorbioideae, tribe Hippomaneae. In: Pope, G.V. (Editor). Flora Zambesiaca. Volume 9, part 4. Royal Botanic Gardens, Kew, Richmond, United Kingdom. pp. 1–337.

Radcliffe-Smith, A., 2001. Genera Euphorbiacearum. Royal Botanic Gardens, Kew, United Kingdom. 455 pp.

Raffauf, R.F., 1996. Plant alkaloids: a guide to their discovery and distribution. Food Products Press, New York, United States. 279 pp.

Raghoebarsing, A.A., Smolders, A.J.P., Schmid, M.C., Rijpstra, W.I.C., Wolters-Arts, M., Derksen, J., Jetten, M.S.M., Schouten, S., Sinninghe Damsté, J.S., Lamers, L.P.M., Roelofs, J.G.M., Op den Camp, H.J.M. & Strous, M., 2005. Methanotrophic symbionts provide carbon for photosynthesis in peat bogs. Nature 436: 1153–1156.

Ragunathan, V. & Sulochana, N., 1994. A new flavonol bioside from the flowers of Hibiscus vitifolius Linn. and its hypoglycaemic activity. Journal of Indian Chemical Society 71: 705–706.

Rahmatullah, M., Sadeak, S.M.I., Bachar, S.C., Hossain, M.T., Al Mamun, A., Montaha, Jahan, N., Chowdhury, M.H., Jahan, R., Nasrin, D., Rahman, M. & Rahman, S., 2010. Brine shrimp toxicity study of different Bangladeshi medicinal plants. Advances in Natural and Applied Sciences 4(2): 163–173.

Raja, D.P., Manickam, V.S., de Britto, A.J., Gopalakrishnan, S., Ushioda, T., Satoh, M., Tanimura, A. & Fuchino, H., 1995. Chemical and chemotaxonomical studies on Dicranopteris species. Chemical and Pharmaceutical Bulletin (Tokyo) 43: 1800–1803.

Rakotoarinivo, M. & Dransfield, J., 2010. New species of Dypsis and Ravenea (Arecaceae) from Madagascar. Kew Bulletin 65: 279–303.

Rakotomalala, M., 2005. Contribution à l'étude de quelques espèces de palmiers endémiques et menacées de Madagascar en vue de leur conservation : cas de Dypsis mananjaranensis (Becc.) Beentje et Dransfield, Dypsis nauseosa (Jum. et H.Perr.) Beentje et Dransfield, Ravenea julietiae Beentje et Ravenea lakatra (Jum.) Beentje dans la forêt dense humide de Manombo (Farafangana). Mémoire de fin d'études, Département des Eaux et Forêts, Ecole Supérieure des Sciences Agronomiques, Université d'Antananarivo, Antananarivo, Madagascar. 65 pp.

Ralantonirina, D., 1993. Aperçu sur les plantes médicinales dans le sud de Madagascar : étude faite sur les adultes dans le périmètre de la réserve spéciale de Beza - Mahafaly. Thèse pour l'obtention du grade de Docteur en médecine, Etablissement d'Enseignement Supérieur des Sciences de la Santé, Faculté de Médecine, Université d'Antananarivo, Madagascar. 95 pp.

Ramcharun, S., Baijnath, H. & van Greuning, J.V., 1990. Some aspects of the reproductive biology of the Ficus natalensis complex in southern Africa. Mitteilungen aus dem Institut für Allgemeine Botanik Hamburg 23a: 451–455.

Ramdhani, S., Barker, N.P. & Baijnath, H., 2008. Exploring the Afromontane centre of endemism: Kniphofia Moench (Asphodelaceae) as a floristic indicator. Journal of Biogeography 35: 2258–2273.

Randal, R.P., 2007. The introduced flora of Australia and its weed status. CRC for Australian Weed Management, Department of Agriculture and Food, Western Australia. CRC for Australian Weed Management, University of Adelaide, Glen Osmond, Australia. 524 pp.

Rao, K.S. & Mishra, S.H., 1988. Antihepatotoxic activity of Sida cordifolia whole plant. Fitoterapia 69(1): 20–23.

Rao, P.R.M., Raju, A.K., Rao, R.V.A. & Rao, B.H.K.M., 1980. Note on a new record of spider predators of Amrasca biguttula biguttula Ishida, a serious pest on mesta. Indian Journal of Agricultural Science 51: 203–204.

Raoufou, R., Kouami, K. & Koffi, A., 2011. Woody plant species used in urban forestry in West Africa: case study in Lomé, capital town of Togo. Journal of Horticulture and Forestry 3(1): 21–31.

Raponda-Walker, A., 1951. Une nouvelle légumineuse du Gabon servant à narcotiser le poisson. Revue Internationale de Botanique Appliquée & d'Agriculture Tropicale 16: 327. Revue Internationale de Botanique Appliquée & d'Agriculture Tropicale 16: 327.

Raponda-Walker, A. & Sillans, R., 1961. Les plantes utiles du Gabon. Paul Lechevalier, Paris, France. 614 pp.

Rasoanaivo, P., Petitjean, A. & Conan, J.Y., 1993. Toxic and poisonous plants of Madagascar: an ethnopharmacological survey. Fitoterapia 64: 117–129.

Rasoanaivo, P., Petitjean, A., Ratsimamanga-Urverg, S. & Rakoto-Ratsimamanga, A., 1992. Medicinal plants used to treat malaria in Madagascar. Journal of Ethnopharmacology 37: 117–127.

Ratsirarson, J. & Ravaosolo, H., 1998. Exploitation du sel gemme aux alentours de la réserve spécial de Beza Mahafaly. Akon'ny Ala 24: 11–18.

Rauschert, S., 1982. Nomina nova generica et combinationes novae Spermatophytorum et Pteridophytorum. Taxon 31(3): 554-563.

Ravagnan, G.M., 2001. Kenaf. In: Raemaekers, R.H. (Editor). Crop production in tropical Africa. DGIC (Directorate General for International Co-operation), Ministry of Foreign Affairs, External Trade and International Co-operation, Brussels, Belgium. pp. 1071–1076.

Ravaoarimanana, L.E., 2005. Maux d'estomac. Fanomezan-danja ny fomba « Ady Gasy » boky faha 3: 11–14.

Raymond, C.A., 1995. Genetic variation in Eucalyptus regnans and Eucalyptus nitens for levels of observed defoliation caused by the Eucalyptus leaf beetle, Chrysophtharta bimaculata Olivier, in Tasmania. Forest Ecology and Management 72(1): 21–29.

Raymundo, A.D. & Bajet, N.B., 2000. Epidemiology and integrated management of abaca bunchy top in the Philippines. In: Molina, A.B., Roa, V.N., Bay-Petersen, J., Carpio, A.T. & Joven, J.E.A. (Editors). Managing banana and citrus diseases. Proceedings of a regional workshop on disease management of banana and citrus through the use of disease-free planting materials held in Davao City, Philippines, 14–16 October 1998. International Network for the Improvement of Banana and Plantain – Asia and the Pacific Network (INIBAP–ASPNET), Los Baños, the Philippines. pp. 89–97.

Razafiarison, C., 1993. Aperçu sur les plantes médicinales dans le sud de Madagascar : étude faite sur les enfants dans le périmètre de la réserve spéciale de Beza - Mahafaly. Thèse pour l'obtention du grade de Docteur en Médecine, Etablissement d'Enseignement Supérieur des Sciences de la Santé, Faculté de Médecine, Université d'Antananarivo, Madagascar. 93 pp.

Razafimahatratra, V., 1996. Méthodologie de suivi écologique Masoala. Acte de l'atelier Suivi et Evaluation, Hotel de Thermes Antsirabe, 7–11 Octobre 1996, Antsirabe, Madagascar. pp. 67–75.

Razafindratovo Ndriana, M., 2006. Une filière menacée : Raphia farinifera. [Internet] Conférences-débats sur des exemples de valorisation durable de produits forestiers. Antananarivo, 19 et 20 avril 2006. <http://iarivo.cirad.fr/ doc/urp_fb/ffem060419/ 04_raphia.pdf>. Accessed January 2011.

Reekmans, M., 1981. Les forêts à Julbernardia globiflora de l'est du Burundi. Bulletin de la Société Royale de Botanique de Belgique 114(1): 49–60.

Reid, K.A., Jäger, A.K., Light, M.E., Mulholland, D.A. & van Staden, J., 2005. Phytochemical and pharmacological screening of Sterculiaceae species and isolation of antibacterial compounds. Journal of Ethnopharmacology 97(2): 285–291.

Reinartz, G.E., Inogwabini, B.I., Ngamankosi, M. & Wema Wema, L., 2006. Effects of forest type and human presence on bonobo (Pan paniscus) density in the Salonga National Park. International Journal of Primatology 27(2): 603–634.

Rendle, B.J., 1969. World timbers. Vol. 1. Europe & Africa. Ernest Benn, London, United Kingdom. 191 pp.

Renoult, J.P., Kjellberg, F., Grout, C., Santoni, S. & Khadari, B., 2009. Cyto-nuclear discordance in the phylogeny of Ficus section Galoglychia and host shifts in plant-pollinator associations. BMC Evolutionary Biology 9: 248.

Restrepo U., G. & Atehortua V., L.M., 1989. Some results from species and provenance trials of Eucalyptus species in the department of Antioquia, Colombia. Forest Genetic Resources 17: 20–23.

Rhodes, R., van Antwerpen, R. & Berry, S.D., 2009. Green manure fallow duration: does it matter? In: Proceedings of the Annual Congress of the South African Sugar Technologists' Association 2009. pp. 570–579.

Ribeiro, A., Romeiras, M.M., Tavares, J. & Faria, M.T., 2010. Ethnobotanical survey in Canhane village, district of Massingir, Mozambique: medicinal plants and traditional knowledge. Journal of Ethnobiology and Ethnomedicine 6: 33.

Richards, P.W., 1963. Ecological notes on West African vegetation: 2. lowland forest of the Southern Bakundu Forest Reserve. Journal of Ecology 51(1): 123–138.

Riedl, H., 2003. Typha L. In: Brink, M. & Escobin, R.P. (Editors). Plant Resources of South-East Asia No 17. Fibre plants. Backhuys Publishers, Leiden, Netherlands. pp. 232–235.

Rietveld, S. & Farazanamalala, J., 2008. Zazamalala forest and botanical garden. [internet] Foundation Friends of Southwestern Madagascar. <http://www.madagaskar.com/>. Accessed January 2010.

Riffle, R.L. & Craft, P., 2003. An encyclopedia of cultivated palms. Timber Press, Portland, Oregon, United States. 516 pp.

Ringrose, C. & Neilsen, W.A., 2005. Growth response of Eucalyptus regnans and soil changes following periodic fertilization. Soil Science Society of America Journal 69: 1806–1812.

Ripley, B., Frole, K. & Gilbert, M., 2010. Differences in drought sensitivities and photosynthetic limitations between co-occurring C3 and C4 (NADP-ME) Panicoid grasses. Annals of Botany 105: 493–503.

Risopoulos, S.R., 1966. Management and use of grass lands: Democratic Republic of Congo. Pasture and Fodder Crops Studies No 1. FAO, Rome, Italy. 212 pp.

Rist, L., Kaiser-Bunbury, C.N., Fleischer-Dogley, F., Edwards, P., Bunbury, N. & Ghazoul, J., 2010. Sustainable harvesting of coco de mer, Lodoicea maldivica, in the Vallée de Mai, Seychelles. Forest Ecology and Management 260(12): 2224–2231.

Riungu, T.C., 1990. The status of linseed, safflower and niger research and production in Kenya. In: Omran, A. (Editor). Oil crops: Proceedings of the 3 meetings held in Pantnagar and Hyderabad, India, 4–17 January 1989. IDRC, Ottawa, Canada. pp. 238–240.

Rizk, A.M., 1991. Poisonous plant contamination of edible plants. CRC Press, Boca Raton, Florida, United States. 183 pp.

Roalson, E.H., 2008. A synopsis of chromosome number variation in the Cyperaceae. Botanical Review 74: 209–393.

Robert, M.L., Lim, K.Y., Hanson, L., Sanchez-Teyer, F., Bennett, M.D., Leitch, A.R. & Leitch, I.J., 2008. Wild and agronomically important Agave species (Asparagaceae) show proportional increases in chromosome number, genome size, and genetic markers with increasing ploidy. Botanical Journal of the Linnean Society 158: 215–222.

Roberts, N., 1988. Dambos in development: management of a fragile ecological resource. Journal of Biogeography 15: 141–148.

Robertson, S.A., 1989. Flowering plants of Seychelles. Royal Botanic Gardens, Kew, Richmond, United Kingdom. 327 pp.

Robinson, B.B. & Johnson, F.L., 1953. Abaca: a cordage fiber. Agriculture Monograph No 21. United States Department of Agriculture, Beltsville, Maryland, United States. 130 pp.

Robinson, B.P. & Potts, R.C., 1950. The history of Hyparrhenia hirta and studies of its flowering habits and seed production. Agronomy Journal 42: 395–397.

Robson, N.K.B., 1966. Celastraceae (incl. Hippocrateaceae). In: Exell, A.W., Fernandes, A. & Wild, H. (Editors). Flora Zambesiaca. Volume 2, part 2. Crown Agents for Oversea Governments and Administrations, London, United Kingdom. pp. 355–418.

Robson, N.K.B., Hallé, N., Mathew, B. & Blakelock, R., 1994. Celastraceae. In: Polhill, R.M. (Editor). Flora of Tropical East Africa. A.A. Balkema, Rotterdam, Netherlands. 78 pp.

Robyns, W., 1929. Flore agrostologique du Congo Belge et du Ruanda–Urundi. Tome 1 : Maydées et Andropogonées. Goemaere, Brussels, Belgium. 229 pp.

Robyns, A., 1957. Le genre Bombax en Afrique tropicale. Bulletin du Jardin Botanique de l'Etat a Bruxelles 27(4): 655–668.

Robyns, A., 1963a. Bombacaceae. In: Robyns, W., Staner, P., Demaret, F., Germain, R., Gilbert, G., Hauman, L., Homès, M., Jurion, F., Lebrun, J., Vanden Abeele, M. & Boutique, R. (Editors). Flore du Congo belge et du Ruanda-Urundi. Spermatophytes. Volume 10. Institut National pour l'Étude Agronomique du Congo belge, Brussels, Belgium. pp. 191–204.

Robyns, A., 1963b. Essai de monographie du genre Bombax s.l. (Bombacaceae). Bulletin du Jardin Botanique de l'Etat a Bruxelles 33(1): 1–144.

Robyns, A., 1975. Thymelaeaceae. In: Bamps, P. (Editor). Flore d'Afrique centrale. Spermatophytes. Jardin botanique national de Belgique, Brussels, Belgium. 68 pp.

Robyns, A., 1995. Passifloraceae. In: Bamps, P. (Editor). Flore d'Afrique centrale. Spermatophytes. Jardin botanique national de Belgique, Brussels, Belgium. 75 pp.

Rodenburg, J. & Johnson, D.E., 2009. Weed management in rice-based cropping systems in Africa. Advances in Agronomy 103: 149–218.

Rodewald-Rudescu, L., 1974. Das Schilfrohr: Phragmites communis Trinius. Die Binnengewässer Band 27, Schweizerbart'sche Verlagsbuchhandlung, Stuttgart, Germany. 202 pp.

Rodin, R.J., 1985. The ethnobotany of the Kwanyama Ovambos. Monographs in Systematic Botany from the Missouri Botanical Garden 9: 1–163.

Rodriguez, E. & Wrangham, R., 1993. Zoopharmacognosy: the use of medicinal plants by animals. In: Downum K.R., Romeo, J.T. & Stafford, H.A. (Editors). Phytochemical potential of tropical plants. Recent advances in phytochemistry. Vol. 27. Plenum Press, New York, United States. pp. 89–105.

Roecklein, J.C. & Leung, P. (Editors), 1987. A profile of economic plants. Transaction Books, New Brunswick, New Jersey, United States. 623 pp.

Rogers, Z.S., 2006. A new species of Malagasy Gnidia and the lectotypification of Octolepis decalepis (Thymelaeaceae). Adansonia séries 3, 28(1): 155–160.

Rogers, Z.S., 2009. A revision of Malagasy Gnidia (Thymelaeaceae, Thymelaeoideae). Annals of the Missouri Botanical Gardens 96(2): 324–368.

Rogers, A.L. & Bailey, E.T., 1963. Salt tolerance trials with forage plants in southwestern Australia. Australian Journal of Experimental Agriculture and Animal Husbandry 3: 125–130.

Rogers, Z.S. & Spencer, M.A., 2006. Typification of plant names in Thymelaeaceae published by Linnaeus and Linnaeus filius. Taxon 55(2): 483–488.

Rolland, R. & Boullet, V., 2005. Mayotte: biodiversité et évaluation patrimoniale. Contribution à la mise en oeuvre de l'inventaire ZNIEFF. 324 pp.

Rommerskirchen, F., Plader, A., Eglinton, G., Chikaraishi, Y. & Rullkoetter, J., 2006. Chemotaxonomic significance of distribution and stable carbon isotopic composition of long-chain alkanes and alkan-1-ols in C4 grass waxes. Organic Geochemistry 37(10): 1303–1332.

Rønsted, N., Weiblen, G.D., Clement, W.L., Zerega, N.J.C. & Savolainen, V., 2008. Reconstructing the phylogeny of figs (Ficus, Moraceae) to reveal the history of the fig pollination mutualism. Symbiosis 45(1–3): 45–55.

Rønsted, N., Salvo, G. & Savolainen, V., 2007. Biogeographical and phylogenetic origins of African fig species (Ficus section Galoglychia). Molecular Phylogenetics and Evolution 43: 190–201.

Roodt, V., 1998. Common wild flowers of the Okavango Delta. Shell Oil Botswana, Gaborone, Botswana. 174 pp.

Roothaert, R.L., 2000. The potential of indigenous and naturalized fodder trees and shrubs for intensive use in central Kenya. PhD thesis, Wageningen University, Wageningen, Netherlands. 168 pp.

Ross, J.H., 1979. A conspectus of the African Acacia species. Memoirs of the Botanical Survey of South Africa No 44. 155 pp.

Ross, R., 1983. Ericaceae. In: Launert, E. (Editor). Flora Zambesiaca. Volume 7, part 1. Flora Zambesiaca Managing Committee, London, United Kingdom. pp. 157–181.

Rothman, J.M., Dierenfeld, E.S., Molina, D.O., Shaw, A.V., Hintz, H.D.F. & Pell, A.N., 2006. Nutritional chemistry of foods eaten by gorillas in Bwindi Impenetrable National Park, Uganda. American Journal of Primatology 68: 675–691.

Rothman, J.M., Plumptre, A.J., Dierenfeld, E.S. & Pell, A.N., 2007. Nutritional composition of the diet of the gorilla (Gorilla beringei): a comparison between two montane habitats. Journal of Tropical Ecology 23: 673–682.

Rotkittikhun, P., Kruatrachue, M., Chaiyarat, R., Ngernsansaruay, C., Pokethitiyook, P., Paijitprapaporn, A. & Baker, A.J.M., 2006. Uptake and accumulation of lead by plants from the Bo Ngam lead mine area in Thailand. Environmental Pollution 144: 681–688.

Rouillard, G. & Guého, J., 2000. Les plantes et leur histoire à l'Ile Maurice. MSM Printers, Port Louis, Mauritius. 752 pp.

Roussel, J., 1995. Pépinières et plantations forestières en Afrique tropicale sèche: manuel à l'usage des ingenieurs et techniciens du reboisement. ISRA/CIRAD, Dakar, Senegal. 435 pp.

Roux, J.P., 2003. Burseraceae. In: Flora of South Africa. South African National Biodiversity Institute, Cape Town, South Africa.

Roux, J. & Coetzee, M.P.A., 2005. First report of pink disease on native trees in South Africa and phylogenetic placement of Erythricium salmonicolor in the Homobasidiomycetes. Plant Disease 89(11): 1158–1163.

Rowell, T.A., 1986. Sedge (Cladium mariscus) in Cambridgeshire: its use and production since the seventeenth century. The Agricultural History Review 34(2): 140–148.

Roy, A., Bandyopadhyay, A., Mahapatra, A.K., Ghosh, S.K., Singh, N.K., Bansal, K.C., Koundal, K.R. & Mohapatra, T., 2006. Evaluation of genetic diversity in jute (Corchorus species) using STMS, ISSR and RAPD markers. Plant Breeding, 125: 292–297.

Royal Botanic Gardens Kew, 2008a. Cladium mariscus. [Internet] Seed Information Database (SID). Version 7.1. <http://data.kew.org/ sid/SidServlet?Source=epic&ID=5908&Num=WP5>. Accessed March 2010.

Royal Botanic Gardens Kew, 2008b. Seed Information Database (SID). Version 7.1. [Internet] <http://data.kew.org/ sid/>. Accessed June 2011.

Ruelland, S., 1988. Dictionnaire tupuri-français-anglais (région de Mindaoré, Tchad). Peeters Publishers, Paris, France. 344 pp.

Ruffo, C.K., Birnie, A. & Tengnäs, B., 2002. Edible wild plants of Tanzania. Technical Handbook No 27. Regional Land Management Unit/ SIDA, Nairobi, Kenya. 766 pp.

Russell, T.A., 1965. The Raphia palms of West Africa. Kew Bulletin 19(2): 173–196.

Russell, T.A., 1968. Palmae. In: Hepper, F.N. (Editor). Flora of West Tropical Africa. Volume 3, part 1. 2nd Edition. Crown Agents for Oversea Governments and Administrations, London, United Kingdom. pp. 159–169.

Russell, I.A. & Kraaij, T., 2008. Effects of cutting Phragmites australis along an inundation gradient, with implications for managing reed encroachment in a South African estuarine lake system. Wetlands Ecology and Management 16(5): 383–393.

Rustiami, H. & Brink, M., 2003. Raphia P. Beauv. In: Brink, M. & Escobin, R.P. (Editors). Plant Resources of South-East Asia No 17. Fibre plants. Backhuys Publishers, Leiden, Netherlands. pp. 211–217.

Rutherford, M.A. & Kangire, A., 1999. Prospects for the management of Fusarium wilt of banana (Panama disease) in Africa. In: Frison, E.A., Gold, C.S., Karamura, E.B. & Sikora, R.A. (Editors). Mobilizing IPM for sustainable banana production in Africa. Proceedings of a workshop on banana IPM held in Nelspruit, South Africa, 23–28 November 1998. INIBAP, Montpellier, France. pp. 177–188.

Sacandé, M. & Pritchard, H.W., 2004. Seed research network on African trees for conservation and sustainable use. Forest Genetic Resources 31: 31–36.

Sadek, L.A., 1996. Annual aboveground primary production and mineral dynamics of Juncus rigidus in a salt marsh of the Mediterranean coastal region of Egypt. Desert Institute Bulletin 46(1): 127–151.

SAGI, undated. Le sisal à Madagascar. [Internet] <http://www.groupe-akesson.com/ le-sisal.php>. Accessed September 2011.

Sahid, M. & Zeven, A.C., 2003. Ceiba pentandra (L.) Gaertn. In: Brink, M. & Escobin, R.P. (Editors). Plant Resources of South-East Asia No 17. Fibre plants. Backhuys Publishers, Leiden, Netherlands. pp. 99–103.

Sakthivadivel, M. & Daniel, T., 2008. Evaluation of certain insecticidal plants for the control of vector mosquitoes viz. Culex quinquefasciatus, Anopheles stephensi and Aedes aegypti. Applied Entomology and Zoology 43(1): 57–63.

Salawu, O.A., Tijani, A.Y., Obidike, I.C., Rafindadi, H.A. & Emeje, M., 2009. Anti-ulcerogenic properties of methanolic root extract of Piliostigma reticulatum (DC) Hoechst (syn. Bauhinia reticulata DC) - Leguminosae in rats. African Journal of Pharmacy and Pharmacology 3(5): 252 258.

Samarajeewa, P.K. & Rathnayaka, R.M.U.S.K., 2004. Disease resistance and genetic variation of wild relatives of okra (Abelmoschus esculentus L.). Annals of the Sri Lanka Department of Agriculture 6: 167–176.

Samaté, A.D., Nacro, M., Menut, C., Lamaty, G. & Bessière, J.M., 1998. Aromatic plants of tropical West Africa. 7. Chemical composition of the essential oils of two Eucalyptus species (Myrtaceae) from Burkina Faso: Eucalyptus alba Muell. and Eucalyptus camaldulensis Dehnhardt. Journal of Essential Oil Research 10(3): 321–324.

Samuelsson, G., Farah, M.H., Claeson, P., Hagos, M., Thulin, M., Hedberg, O., Warfa, A.M., Hassan, A.O., Elmi, A.H., Abdurahman, A.D., Elmi, A.S., Abdi, Y.A. & Alin, M.H., 1992. Inventory of plants used in traditional medicine in Somalia. 3. Plants of the families Lauraceaea to Papilionaceae. Journal of Ethnopharmacology 37: 93–112.

Sancheti, S., Sancheti, S., Bafna, M., Kim, H.-R., You, Y.-H. & Seo, S.-Y., 2011. Evaluation of antidiabetic, antihyperlipidemic and antioxidant effects of Boehmeria nivea (L.) Gaudich., Urticaceae, root extract in streptozotocin-induced diabetic rats. Revista Brasileira de Farmacognosia 21(1): 146–154.

Sandjo, L.P., Hannewald, P., Yemloul, M., Kirsch, G. & Ngadjuia, B.T., 2008. Triumfettamide and triumfettoside Ic, two ceramides and other secondary metabolites from the stems of wild Triumfetta cordifolia A. Rich. (Tiliaceae). Helvetica Chimica Acta 91(7): 1326–1335.

Sandy, M. & Bacon, L., 2001. Tensile testing of raffia. Journal of Materials Science Letters 20: 529–530.

Sangaré, M., Fernandez-Rivera, S., Hiernaux, P. & Pandey, V.S., 2003. The effect of supplementation with fresh browse of Ziziphus mauritiana or Combretum aculeatum on feed intake, nitrogen utilization and growth of grazing range sheep. Tropical Animal Health and Production 35(5): 465–76.

Sarojini, G., Rao, K.C., Tulpule, P.G. & Lakshminarayana, G., 1985. Effects of processing on physicochemical properties and fatty acid composition of Hibiscus sabdariffa seed oil. Journal of the American Oil Chemists' Society 62: 728–730.

Sarrailh, J.-M., Baret, S., Rivière, E. & le Bourgeois, T., 2007. Arbres et arbustes indigènes de la Réunion. (CD-ROM). CIRAD, Saint-Denis, Réunion.

Sarwatt, S. & Mollel, E., undated. Grassland and pasture crops. [Internet] Country Pasture/Forage Resource Profiles: United Republic of Tanzania. FAO, Rome, Italy. <http://www.fao.org/ ag/AGP/AGPC/doc/Counprof/ tanz.htm>. Accessed April 2011.

Sasikumar, J.M., Jinu, U. & Shamna, R., 2011. In vitro antioxidant activity and HPTLC analysis of root of Pandanus odoratissimus L. International Journal of Pharmacy and Pharmaceutical Sciences 3(1): 64–67.

Saunders, M.J., Jones, M.B. & Kansiime, F., 2007. Carbon and water cycles in tropical papyrus wetlands. Wetlands Ecology and Management 15(6): 489–498.

Savadogo, P., Sawadogo, L. & Tiveau, D., 2007. Effects of grazing intensity and prescribed fire on soil physical and hydrological properties and pasture yield in the savanna woodlands of Burkina Faso. Agriculture, Ecosystems and Environment 118: 80–92.

Savill, P.S. & Fox, J.E.D., 1967. Trees of Sierra Leone. Forest Department, Freetown, Sierra Leone. 316 pp.

Sawadogo, L., Tiveau, D. & Nygard, R., 2005. Influence of selective tree cutting, livestock and prescribed fire on herbaceous biomass in the savannah woodlands of Burkina Faso, West Africa. Agriculture, Ecosystems & Environment 105(1–2): 335–345.

Saxena, A.K., Jain, S.K. & Saksena, S.B., 1981. A note on new diseases caused by Alternaria alternata. National Academy Science Letters 4(7): 267.

Saxena, P.R., Tangri, K.K. & Bhargava, K.P., 1966. Identification of acetylcholine, histamine, and 5-hydroxytryptamine in Girardinia heterophylla (Decne.). Canadian Journal of Physiology and Pharmacology 44: 621–627.

Schaller, M., Schroth, G., Beer, J. & Jiménez, F., 2003. Species and site characteristics that permit the association of fast-growing trees with crops: the case of Eucalyptus deglupta as coffee shade in Costa Rica. Forest Ecology and Management 175(1–3): 205–215.

Schatz, G.E., 2001. Generic tree flora of Madagascar. Royal Botanic Gardens, Kew, Richmond, United Kingdom. 477 pp.

Schatz, G., undated. A catalogue of the vascular plants of Madagascar. [Internet]. Missouri Botanical Garden, St. Louis, United States. <http://www.tropicos.org/Project/MADA>. Accessed January 2009 - July 2011.

Schippers, R.R., 2000. African indigenous vegetables. An overview of the cultivated species. Natural Resources Institute/ACP-EU Technical Centre for Agricultural and Rural Cooperation, Chatham, United Kingdom. 214 pp.

Schippers, R.R., 2002. African indigenous vegetables, an overview of the cultivated species 2002. Revised edition on CD-ROM. National Resources International Limited, Aylesford, United Kingdom.

Schmidt, E., Lötter, M. & McCleland, W., 2002. Trees and shrubs of Mpumalanga and Kruger National Park. Jacana Publishers, Johannesburg, South Africa. 702 pp.

Schnell, R., 1953a. Combretum aculeatum Ventenat: Combretaceae. Icones Plantarum Africanarum 1, No 4. 4 pp.

Schnell, R., 1953b. Sarcophrynium (Marantacées) ouest-africains. Bulletin de l'Institut Française d'Afrique Noire 15: 1390–1393.

Scholz, H. & Scholz, U., 1983. Flore descriptive des Cypéracées et Graminées du Togo. J. Cramer, Vaduz, Liechtenstein. 360 pp.

Scott, A.J., 1993. Myrtacées. In: Bosser, J., Cadet, T., Guého, J. & Marais, W. (Editors). Flore des Mascareignes. Familles 90–106. The Sugar Industry Research Institute, Mauritius, l'Institut Français de Recherche Scientifique pour le Développement en Coopération (ORSTOM), Paris, France & Royal Botanic Gardens, Kew, Richmond, United Kingdom. 70 pp.

Seal, S. & Gupta, K., 1998. Germination behaviour of two species of Sida, a medicinal plant. Tropical Ecology 39(2): 279–281.

Sebsebe Demissew, 1999. Tiliaceae. In: Thulin, M. (Editor). Flora of Somalia. Volume 2. Angiospermae (Tiliaceae-Apiaceae). Royal Botanic Gardens, Kew, Richmond, United Kingdom. pp. 5–21.

Sebsebe Demissew, 2009. Gleicheniaceae. In: Hedberg, I., Friis & Hedberg, E. (Editors). Flora of Ethiopia and Eritrea. Volume 1. Lycopodiaceae to Pinaceae. The National Herbarium, Addis Ababa University, Addis Ababa, Ethiopia and Department of Systematic Botany, Uppsala University, Uppsala, Sweden. pp. 31–32.

Seck, A., Sow, I. & Niass, M., 1999. Senegal. In: Chweya, J.A. & Eyzaguirre, P.B. (Editors). The biodiversity of traditional leafy vegetables. IPGRI, Rome, Italy. pp. 83–110.

Seegeler, C.J.P., 1983. Oil plants in Ethiopia, their taxonomy and agricultural significance. Agricultural Research Reports 921. Pudoc, Wageningen, Netherlands. 368 pp.

Seignobos, C. & Schwendiman, J., 1991. Les cotonniers traditionnels du Cameroun. Coton et Fibres Tropicales 46(4): 309–333.

Selvaraj, C. & Narayanasamy, P., 1991. Effect of plant extracts in controlling rice tungro. International Rice Research Newsletter 16(2): 21–22.

Sembène, M. & Delobel, A., 1998. Genetic differentiation of groundnut seed-beetle populations in Senegal. Entomologia Experimentalis et Applicata 87(2): 171–180.

SEPASAL, 1999. Survey of Economic Plants for Arid and Semi-Arid Lands. [Internet] Royal Botanic Gardens, Kew, Richmond, United Kingdom. <http://www.kew.org/ ceb/sepasal/>. Accessed June 2011.

SEPASAL, 2003. Eragrostis pallens. [Internet] Survey of Economic Plants for Arid and Semi-Arid Lands (SEPASAL) database. Royal Botanic Gardens, Kew, Richmond, United Kingdom. <http://www.kew.org/ ceb/sepasal/>. Accessed May 2011.

SEPASAL, 2009a. Abutilon angulatum. [Internet] Survey of Economic Plants for Arid and Semi-Arid Lands (SEPASAL) database. Royal Botanic Gardens, Kew, Richmond, United Kingdom. <http://www.kew.org/ ceb/sepasal/>. Accessed November 2009.

SEPASAL, 2009b. Abutilon hirtum. [Internet] Survey of Economic Plants for Arid and Semi-Arid Lands (SEPASAL) database. Royal Botanic Gardens, Kew, Richmond, United Kingdom. <http://www.kew.org/ ceb/sepasal/>. Accessed November 2009.

SEPASAL, 2009c. Ficus capreifolia. [Internet] Survey of Economic Plants for Arid and Semi-Arid Lands (SEPASAL) database. Royal Botanic Gardens, Kew, Richmond, United Kingdom. <http://www.kew.org/ ceb/sepasal/>. Accessed June 2009.

SEPASAL, 2009d. Grewia trichocarpa. [Internet] Survey of Economic Plants for Arid and Semi-Arid Lands (SEPASAL) database. Royal Botanic Gardens, Kew, Richmond, United Kingdom. <http://www.kew.org/ ceb/sepasal/>. Accessed January 2009.

SEPASAL, 2009e. Piliostigma thonningii. [Internet] Survey of Economic Plants for Arid and Semi-Arid Lands (SEPASAL) database. Royal Botanic Gardens, Kew, Richmond, United Kingdom. <http://www.kew.org/ ceb/sepasal/>. Accessed November 2009.

SEPASAL, 2009f. Pouzolzia mixta. [Internet] Survey of Economic Plants for Arid and Semi-Arid Lands (SEPASAL) database. Royal Botanic Gardens, Kew, Richmond, United Kingdom. <http://www.kew.org/ ceb/sepasal/>. Accessed March 2009.

SEPASAL, 2009g. Xerophyta squarrosa. [Internet] Survey of Economic Plants for Arid and Semi-Arid Lands (SEPASAL) database. Royal Botanic Gardens, Kew, Richmond, United Kingdom. <http://www.kew.org/ ceb/sepasal/>. Accessed February 2009.

SEPASAL, 2010a. Cochlospermum planchonii. [Internet] Survey of Economic Plants for Arid and Semi-Arid Lands (SEPASAL) database. Royal Botanic Gardens, Kew, Richmond, United Kingdom. <http://www.kew.org/ ceb/sepasal/>. Accessed April 2010.

SEPASAL, 2010b. Combretum aculeatum. [Internet] Survey of Economic Plants for Arid and Semi-Arid Lands (SEPASAL) database. Royal Botanic Gardens, Kew, Richmond, United Kingdom. <http://www.kew.org/ ceb/sepasal/>. Accessed May 2010.

SEPASAL, 2010c. Commiphora multijuga. [Internet] Survey of Economic Plants for Arid and Semi-Arid Lands (SEPASAL) database. Royal Botanic Gardens, Kew, Richmond, United Kingdom. <http://www.kew.org/ ceb/sepasal/>. Accessed August 2010.

SEPASAL, 2010d. Diospyros lycioides. [Internet] Survey of Economic Plants for Arid and Semi-Arid Lands (SEPASAL) database. Royal Botanic Gardens, Kew, Richmond, United Kingdom. <http://www.kew.org/ ceb/sepasal/>. Accessed August 2010.

SEPASAL, 2010e. Livistona carinensis. [Internet] Survey of Economic Plants for Arid and Semi-Arid Lands (SEPASAL) database. Royal Botanic Gardens, Kew, Richmond, United Kingdom. <http://www.kew.org/ ceb/sepasal/>. Accessed October 2010.

SEPASAL, 2010f. Sterculia africana. [Internet] Survey of Economic Plants for Arid and Semi-Arid Lands (SEPASAL) database. Royal Botanic Gardens, Kew, Richmond, United Kingdom. <http://www.kew.org/ ceb/sepasal/>. Accessed November 2010.

SEPASAL, 2010g. Hibiscus panduraeformis. [Internet] Survey of Economic Plants for Arid and Semi-Arid Lands (SEPASAL) database. Royal Botanic Gardens, Kew, Richmond, United Kingdom. <http://www.kew.org/ ceb/sepasal/. Accessed October 2010.

SEPASAL, 2011a. Gossypium herbaceum. [Internet] Survey of Economic Plants for Arid and Semi-Arid Lands (SEPASAL) database. Royal Botanic Gardens, Kew, Richmond, United Kingdom. <http://www.kew.org/ ceb/sepasal/>. Accessed September 2011.

SEPASAL, 2011b. Hibiscus tiliaceus. [Internet] Survey of Economic Plants for Arid and Semi-Arid Lands (SEPASAL) database. Royal Botanic Gardens, Kew, Richmond, United Kingdom. <http://www.kew.org/ ceb/sepasal/>. Accessed August 2011.

SEPASAL, 2011c. Hibiscus vitifolius. [Internet] Survey of Economic Plants for Arid and Semi-Arid Lands (SEPASAL) database. Royal Botanic Gardens, Kew, Richmond, United Kingdom. <http://www.kew.org/ ceb/sepasal/>. Accessed August 2011.

SEPASAL, 2011d. Phoenix reclinata. [Internet] Survey of Economic Plants for Arid and Semi-Arid Lands (SEPASAL) database. Royal Botanic Gardens, Kew, Richmond, United Kingdom. <http://www.kew.org/ ceb/sepasal/>. Accessed February 2011.

SEPASAL, 2011e. Sansevieria aethiopica. [Internet] Survey of Economic Plants for Arid and Semi-Arid Lands (SEPASAL) database. Royal Botanic Gardens, Kew, Richmond, United Kingdom. <http://www.kew.org/ ceb/sepasal/>. Accessed March 2011.

SEPASAL, 2011f. Sesamum triphyllum. [Internet] Survey of Economic Plants for Arid and Semi-Arid Lands (SEPASAL) database. Royal Botanic Gardens, Kew, Richmond, United Kingdom. <http://www.kew.org/ ceb/sepasal/>. Accessed August 2011.

SEPASAL, 2011g. Hibiscus micranthus. [Internet] Survey of Economic Plants for Arid and Semi-Arid Lands (SEPASAL) database. Royal Botanic Gardens, Kew, Richmond, United Kingdom. <http://www.kew.org/ ceb/sepasal/. Accessed August 2011.

Seshu Reddy, K.V., Gold, C.S. & Ngode, L., 1999. Cultural control strategies for banana weevil, Cosmopolites sordidus Germar. In: Frison, E.A., Gold, C.S., Karamura, E.B. & Sikora, R.A. (Editors). Mobilizing IPM for sustainable banana production in Africa. Proceedings of a workshop on banana IPM held in Nelspruit, South Africa, 23–28 November 1998. INIBAP, Montpellier, France. pp. 51–57.

Sethmann, A., 2004. Girardinia diversifolia (Link) Friis (Urticaceae) – eine neue Faserpflanze – Untersuchungen zu den morphologischen und mechanischen Fasercharakteristika. Doctoral thesis, Universität Hamburg, Hamburg, Germany. 110 pp.

Sethmann, A. & Dreyling, G., 2001. Girardinia diversifolia (Link) Friis: morphological and anatomical characteristics of a fibre plant. Journal of Applied Botany 75(3–4): 112–117.

Seyani, J.H., 1991. The genus Dombeya (Sterculiaceae) in continental Africa. Opera Botanica Belgica 2. National Botanic Garden of Belgium, Meise, Belgium. 186 pp.

Shackleton, C.M., 2000. Stump size and the number of coppice shoots for selected savanna tree species. South African Journal of Botany 66(2): 124–127.

Shackleton, S.E., Dzerefos, C.M., Shackleton, C.M. & Mathabela, F.R., 1998. Use and trading of wild edible herbs in the central lowveld savanna region, South Africa. Economic Botany 52(3): 251–259.

Shamsuddin Ahmad & van der Vossen, H.A.M., 2003a. Hibiscus cannabinus L. In: Brink, M. & Escobin, R.P. (Editors). Plant Resources of South-East Asia No 17. Fibre plants. Backhuys Publishers, Leiden, Netherlands. pp. 156–162.

Shamsuddin Ahmad & van der Vossen, H.A.M., 2003b. Hibiscus sabdariffa L. In: Brink, M. & Escobin, R.P. (Editors). Plant Resources of South-East Asia No 17. Fibre plants. Backhuys Publishers, Leiden, Netherlands. pp. 162–167.

Shanbhag, T., Dattachaudhuri, A., Shenoy, S. & Bairy, K.L., 2009. Wound healing activity of Abroma augusta in Wistar rats. Asian Pacific Journal of Tropical Medicine 2(4): 6–10.

Shapcott, A., Dowe, J.L. & Ford, H., 2009. Low genetic diversity and recovery implications of the vulnerable Bankoualé palm Livistona carinensis (Arecaceae), from north-eastern Africa and the southern Arabian Peninsula. Conservation Genetics 10: 317–327.

Sharaf, A., Sorour, A., Gomaa, N. & Youssef, M., 1972. Some pharmacological studies on Hyphaene thebaica Mart. fruit. Qualitas Plantarum 22(1): 83–90.

Sharman, M., Thomas, J.E., Skabo, S. & Holton, T.A., 2008. Abacá bunchy top virus, a new member of the genus Babuvirus (family Nanoviridae). Archives of Virology 153: 135–147.

Shava, S. & Mapaura, A., 2002. Traditional uses of indigenous grasses of Zimbabwe. Sabonet News 7(3): 193–197.

Shaw, C.T., 1945. Bead-making with a bow-drill in the Gold Coast. Journal of the Royal Anthropological Institute of Great Britain and Ireland 75(1/2): 45–50.

Sheil, D., 1994. Naturalized and invasive plant species in the evergreen forests of the East Usambara Mountains, Tanzania. African Journal of Ecology 32(1): 66–71.

Shilling, D.G., Beckwick, T.A., Gaffney, J.F., McDonald, S.K., Chase, C.A. & Johnson, E.R.R.L., 1997. Ecology, physiology, and management of Cogongrass (Imperata cylindrica). Final Report. Florida Institute of Phosphate Research, Bartow, Florida, USA. 128 pp.

Shrestha, R., 1997. Cytological studies in Girardinia diversifolia (Link) Friis. Pakistan Journal of Botany 29(2): 263–269.

Siemonsma, J.S., 1991. Abelmoschus: a taxonomical and cytogenetical overview. In: IBPGR. Report of an international workshop on okra genetic resources, held at the National Bureau for Plant Genetic Resources (NBPGR), New Delhi, India, 8–12 October 1990. International Crop Network Series 5. International Board for Plant Genetic Resources (IBPGR), Rome, Italy. pp. 52–68.

Silberbauer-Gottsberger, 1984. Fruit dispersal and trypanocarpy in Brazilian Cerrado grasses. Plant Systematics and Evolution 147: 1–27.

Simmen, B., Hladik, A., Ramasiarisoa, P.L., Iaconelli, S. & Hladik, C.M., 1999. Taste discrimination in lemurs and other primates, and the relationships to distribution of plant allelochemichals in different habitats of Madagascar. In: Rakotosamimanana, B., Rasamimanana, H., Ganzhorn, J.U. & Goodman, S.M. (Editors). New Directions in Lemur Studies. Kluwer Academic/Plenum Press, New York, United States. pp. 201–219.

Simmons, M.P. & Hedin, J.P., 1999. Relationships and morphological character change among genera of Celastraceae sensu lato (including Hippocrateaceae). Annals of the Missouri Botanical Garden 86(3): 723–757.

Simmons-Boyce, J.L., Tinto, W.F., McLean, S. & Reynolds, W.F., 2004. Saponins from Furcraea selloa var. marginata. Fitoterapia 75(7–8): 634–638.

Simpson, D.A., 1992. A revision of the genus Mapania (Cyperaceae). Royal Botanic Gardens, Kew, Richmond, United Kingdom. 189 pp.

Simpson, D.A., 2006. Flora da Reserva Ducke, Amazonas, Brasil: Cyperaceae. Rodriguésia 57(2): 171–188.

Simpson, D.A. & Inglis, C.A., 2001. Cyperaceae of economic, ethnobotanical and horticultural importance: a checklist. Kew Bulletin 56(2): 257–360.

Singh, D.P., 1976. Jute, Corchorus spp. Tiliaceae. In: Simmonds, N.W. (Editor). Evolution of crop plants. Longman, London, United Kingdom. pp. 290–291.

Singh, S.C. & Shrestha, R., 1988. Girardinia diversifolia (Urticaceae), a non-conventional fiber resource in Nepal. Economic Botany 42(3): 445–447.

Singh, N. & Srivastava, J.K., 2007. Comparison of the ability of two grasses viz., Phragmites karka (Retz.) Trin. ex. Steud. and Vetiveria zizanioides (L.) Nash to improve surface water quality in a constructed wetland. International Journal of Water 3(3): 266–274.

Singh, U., Wadhwani, A.M. & Johri, B.M., 1983. Dictionary of economic plants of India. Indian Council of Agricultural Research, New Delhi, India.

Singh, B., Rai, M., Kalloo, G., Satpathy, S. & Pandey, K.K., 2007. Wild taxa of okra (Abelmoschus species): reservoir of genes for resistance to biotic stresses. Acta Horticulturae 752: 323–328.

Sinha, S. & Osman, S.M., 1982. Fatty acid composition of Hibiscus ficulneus seed oil. Journal of the Science of Food and Agriculture 33(10): 1010–1012.

Sinha, M.K., Mandal, R.K. & Palve, S.M., 2003. Preliminary evaluation of wild species of jute (Corchorus species). Plant Genetic Resources Newsletter 134: 10–12.

Sinnot, E.W. & Bloch, R., 1943. Development of the fibrous net in the fruit of various races of Luffa cylindrica. Botanical Gazette 105(1): 90–99.

Skarpe, C., Jansson, I., Seljeli, L., Bergström, R. & Røskaft, E., 2007. Browsing by goats on three spatial scales in a semi-arid savanna. Journal of Arid Environments 68: 480–491.

Skerman, P.J. & Riveros, F., 1990. Tropical grasses. FAO Plant Production and Protection Series No 23. Rome, Italy. 832 pp.

Sleumer, H., 1970. Le genre Paropsia Noronha ex Thouars (Passifloraceae). Bulletin du Jardin Botanique National de Belgique 40(1): 49–75.

Sleumer, H., 1971. Le genre Casearia Jacq. (Flacourtiaceae) en Afrique, à Madagascar et aux Mascareignes. Bulletin du Jardin Botanique National de Belgique 41: 397–426.

Sleumer, H., 1975. Flacourtiaceae. In: Polhill, R.M. (Editor). Flora of Tropical East Africa. Crown Agents for Oversea Governments and Administrations, London, United Kingdom. 68 pp.

Sleumer, H. & Bamps, P., 1976. Flacourtiaceae (seconde partie). In: Bamps, P. (Editor). Flore d'Afrique centrale. Spermatophytes. Jardin botanique national de Belgique, Brussels, Belgium. 45 pp.

Slingerland, M. & Kiéma, A., 2001. Vegetation resources in Sahelian villages. Advances in Geoecology 33: 179–192.

Smith, C.W., 1995. Crop production: evolution, history, and technology. John Wiley & Sons, New York, United States. 469 pp.

Smith, L.B. & Ayensu, E.S., 1975. Velloziaceae. In: Polhill, R.M. (Editor). Flora of Tropical East Africa. Crown Agents for Oversea Governments and Administrations, London, United Kingdom. 9 pp.

Smith, C.W. & Cothren, J.T. (Editors), 1999. Cotton: origin, history, technology, and production. John Wiley & Sons, New York, United States. 850 pp.

Snogerup, S., 1993. A revision of Juncus subgen. Juncus (Juncaceae). Willdenowia 23(1/2): 23–73.

Soderholm, P.K., 1973. Dombeya 'Seminole' and D. 'Pinwheel', new cultivars for landscaping in the subtropics. Proceedings of the Florida State Horticultural Society 1973: 452–453.

Sölch, A., 1969. Velloziaceae. Prodromus einer Flora von Südwestafrika. No 152. J. Cramer, Germany. 3 pp.

Sommerlatte, H. & Sommerlatte, M., 1990. A field guide to the trees and shrubs of the Imatong Mountains, southern Sudan. Deutsche Gesellschaft fur Technische Zusammmenarbeit (GTZ), Nairobi, Kenya. 372 pp.

Sonibare, M.A., Sonibare, O.O., Akharame, O.E. & Soladoye, M.O., 2009. Chemical composition of essential oils of Ficus elasticoidies de Wild., Ficus ovata Vahl and Ficus natalensis subsp. leprieurii (Miq.) C.C. Berg from Nigeria. Journal of Essential Oil-Bearing Plants 12(3): 282–286.

Sosa, A. & Carmelo, R., 2010. Flavonoids from Urena sinuata L. Avances en Química 5(2): 2010, 95–98.

Sosef, M.S.M., Wieringa, J.J., Jongkind, C.C.H., Achoundong, G., Azizet Issembé, Y., Bedigian, D., van den Berg, R.G., Breteler, F.J., Cheek, M., Degreef, J., Faden, R.B., Goldblatt, P., van der Maesen, L.J.G., Ngok Banak, L., Niangadouma, R., Nzabi, T., Nziengui, B., Rogers, Z.S., Stévart, T., van Valkenburg, J.L.C.H., Walters, G. & de Wilde, J.J.F.E., 2006. Check-list des plantes vasculaires du Gabon. Checklist of Gabonese vascular plants. Scripta Botanica Belgica. Volume 35. National Botanic Garden of Belgium. 438 pp.

South African National Standard, 2004. Specification for grass. [Internet] SANS 10407:2004. Thatched roof construction. Edition 1. South African Thatchers Association, Lyttelton, South Africa. <http://www.sa-thatchers.co.za/ wp-content/uploads/2010/09/ SpecificationForGrass.pdf>. Accessed April 2011.

Southon, I.W., Bisby, F.A., Buckingham, J. & Harborne, J.B., 1994. Phytochemical dictionary of the Leguminosae. Volume 1: Plants and their constituents. Chapman and Hall, London, United Kingdom. 1051 pp.

Sowemimo, A.A., Fakoya, F.A., Awopetu, I., Omobuwajo, O.R. & Adesanya, S.A., 2007. Toxicity and mutagenic activity of some selected Nigerian plants. Journal of Ethnopharmacology 113(3): 427–432.

Speichert, G. & Speichert, S., 2008. Timber Press pocket guide to water garden plants. Timber Press, Portland, Oregon, United States. 210 pp.

Stamp, J., 1998. Indigenous agroforestry and sustainable development in Mutoko communal district, Zimbabwe. PhD thesis, Department of Geography, University of Toronto, Canada. 330 pp.

Staner, P., 1935. Les Thyméléacées de la flore du Congo. Bulletin du Jardin Botanique de l'Etat (Bruxelles) 13: 321–371.

Stapf, O., 1902–1904. Apocynaceae. In: Thiselton-Dyer, W.T. (Editor). Flora of tropical Africa. Volume 4(1). Lovell Reeve & Co, London, United Kingdom. pp. 24–231.

Stapf, O., 1917–1934. Gramineae. In: Prain, D. (Editor). Flora of tropical Africa. Volume 9. L. Reeve & Co., Ashford, United Kingdom. 1100 pp.

Staples, G.W., 2006. Revision of Asiatic Poraneae (Convolvulaceae): Cordisepalum, Dinetus, Duperreya, Porana, Poranopsis and Tridynamia. Blumea 51(3): 403–491.

Staples, G.W. & Herbst, D.R., 2005. A tropical garden flora: plants cultivated in the Hawaiian Islands and other tropical places. Bishop Museum Press, Honolulu, United States. 908 pp.

Staugärd, F. (Editor), 1989. Traditional medicine in Botswana. Ipelegeng Publishers, Gaborone, Botswana. 324 pp.

Stave, J., Oba, G., Nordal, I. & Stenseth, N.C., 2007. Traditional ecological knowledge of a riverine forest in Turkana, Kenya: implications for research and management. Biodiversity Conservation 16: 1471–1489.

Stefanesco, E. & Bintoni-Juliassi, O., 1982. 101 wild fodder and food plants of Angonia province of Tete Mozambique. Field Document No 39. Ministry of Agriculture, Food and Agriculture Organization of the United Nations, Maputo, Mozambique. 208 pp.

Steinkraus, K.H. (Editor), 1996. Handbook of indigenous fermented foods. 2nd edition. Marcel Dekker, New York, United States. 776 pp.

Stevels, J.M.C., 1990. Légumes traditionnels du Cameroun: une étude agrobotanique. Wageningen Agricultural University Papers 90–1. Wageningen Agricultural University, Wageningen, Netherlands. 262 pp.

Stiles, D., 1994. Tribals and trade: a strategy for cultural and ecological survival. Ambio 23(2): 106–111.

Stiles, D., 1998. The Mikea hunter-gatherers of southwest Madagascar: ecology and socioeconomics. African Study Monographs 19(3): 127–148.

Stone, B.C., 1970. Observations on the genus Pandanus in Madagascar. Botanical Journal of the Linnean Society 63: 97–131.

Stone, B.C., 1973. A synopsis of the African species of Pandanus. Annals of the Missouri Botanical Garden 60(2): 260–272.

Stone, B.C., 1974. Towards an improved infrageneric classification in Pandanus (Pandanaceae). Botanische Jahrbücher für Systematik, Pflanzengeschichte und Pflanzengeographie 94(4): 459–540.

Stone, B.C., 1983. A guide to collecting Pandanaceae (Pandanus, Freycinetia, and Sararanga). Annals of the Missouri Botanical Garden 70: 137–145.

Stone, B.C., 1991. Pandanus Parkinson. In: Verheij, E.W.M. & Coronel, R.E. (Editors). Plant resources of South-East Asia No 2. Edible fruits and nuts. Pudoc, Wageningen, Netherlands. pp. 240–243.

Storrs, A.E.G., 1995. Know your trees: Some common trees found in Zambia. Regional Conservation Unit, Ndola, Zambia. 380 pp.

Strack, M. & Waddington, J.M., 2008. Spatiotemporal variability in peatland subsurface methane dynamics. Journal of Geophysical Research [Biogeosciences] 113(G2): G02010/1 G02010/12.

Suleman, K.M. & Nadeem, K., 1995. Suitability of home grown paper mulberry (Broussonetia papyrifera) for pulp and paper manufacture. Pakistan Journal of Forestry 45(4): 158–162.

Sundar Rao, K. & Lakshminarayana, G., 1985. Fatty acid compositions of seed oils of seven Hibiscus species of Malvaceae. Journal of the American Oil Chemists' Society 62(4): 714–715.

Sundar Rao, K., Pantulu, A.J. & Lakshminarayana, G., 1983. Analysis of Calotropis gigantea, Acacia caesia, and Abelmoschus ficulneus seeds. Journal of the American Oil Chemists' Society 60(7): 1259–1261.

Sundararajan, G. & Kumuthakalavalli, R., 2001. Antifeedant activity of aqueous extract of Gnidia glauca Gilg. and Toddalia asiatica Lam. on the gram pod borer, Helicoverpa armigera (hbn). Journal of Environmental Biology 22(1): 11–14.

Sunderland, T.C.H., 1998a. Diversity and abundance of rattans in the Campo Faunal Reserve, Cameroon and an estimate of market value. Technical Note No 2. African Rattan Research Programme.

Sunderland, T.C.H., 1998b. The rattans of Rio Muni, Equatorial Guinea: utilisation, biology and distribution. A report for the European Union Project No 6 ACP-EG-020: Proyecto Conservacion y Utilizacion Racional de los Ecosistemas Forestales de Guinea Ecuatorial (CUREF). Ministerio de Pesca y Forestal, Guinea Ecuatorial. 28 pp.

Sunderland, T.C.H., 2001a. Rattan resources and use in West and Central Africa. Unasylva 52(205): 18–26.

Sunderland, T.C.H., 2001b. The taxonomy, ecology and utilisation of African rattans (Palmae: Calamoideae). PhD Thesis, University College, London, United Kingdom. 359 pp.

Sunderland, T.C.H., 2002a. Hapaxanthy and pleonanthy in African rattans (Palmae: Calamoideae). Journal of Bamboo and Rattan 1(2): 131–139.

Sunderland, T.C.H., 2002b. Two new species of rattan (Palmae: Calamoideae) from Africa. Journal of Bamboo and Rattan 1(4): 361–369.

Sunderland, T.C.H., 2003. Two new species of rattan (Palmae: Calamoideae) from the forests of West and Central Africa. Kew Bulletin 58: 987–990.

Sunderland, T.C.H., 2007. Field guide to the rattan palms of Africa. Kew Publishing, Royal Botanic Gardens, Kew, Richmond, United Kingdom. 66 pp.

Sunderland, T.C.H. & Obama, C., 1999. A preliminary market survey of the non-wood forest products of Equatorial Guinea. In: Sunderland, T.C.H., Clark, L.E. & Vantomme, P. (Editors). Non-wood forest products of Central Africa: current research issues and prospects for conservation and development. FAO, Rome, Italy. pp. 211–220.

Sunderland, T.C.H., Balinga, M.P.B. & Groves, J., 2002. The cane bridges of the Takamanda region, Cameroon. Palms 46(2): 93–95.

Sunderland, T.C.H., Defo, L., Ndam, N., Dione, M. & Tamnjong, I., 2003. A socio-economic profile of the rattan trade in Cameroon. In: Sunderland, T.C.H. & Profizi, J.P. (Editors). New research on African rattans. Proceedings of the CARPE-funded International Expert Meeting on the Rattans of Africa, held at the Limbe Botanic Garden, Cameroon, 1–3 February 2000. International Network for Bamboo and Rattan (INBAR), Beijing, China. pp. 115–140.

Sunderland, T.C.H., Beligné, V., Bonnéhin, L., Ebanyenle, E., Oteng-Amoako, A. & Zouzou, E.-J., 2005. Taxonomy, population dynamics and utilisation of the rattan palms of the Upper Guinea forests of West Africa. In: Bongers, F., Parren, M.P.E. & Traoré, D. (Editors). Forest climbing plants of West Africa. Diversity, ecology and management. CABI Publishing, Wallingford, United Kingdom. pp. 147–166.

Sunderland, T.C.H., Balinga, M.P.B., Asaha, S. & Malleson, R., 2008. The utilization and management of African rattans: constraints to sustainable supply through cultivation. Forests, Trees and Livelihoods 38(4): 337–353.

Swabey, C., 1970. The endemic flora of the Seychelle islands and its conservation. Biological Conservation 2(3): 171–178.

Swanepoel, B.A., 2006. The vegetation ecology of Uzemvelo nature reserve. [Internet] Magster scientia. M.Sc. thesis University of Pretoria. pp.37–71. <http://upetd.up.ac.za/ thesis/available/etd-09142007-143511/unrestricted/ dissertation.pdf>. Accessed April 2009.

Szlachetko, D.L & Kowalkowska, A., 2007. Contributions to the orchid flora of Guinea, West Africa. Polish Botanical Studies 25: 3–259.

Szlachetko, D.L. & Olszewski, T.S., 1998. Orchidaceae (Volume 1). Flore du Cameroun. Volume 34. Muséum National d'Histoire Naturelle, Paris, France. pp. 2–320.

Szlachetko, D.L., Sawicka, M. & Kras-Lapinska, M., 2004. Orchidaceae (Volume 1). Flore du Gabon. Volume 36. Muséum National d'Histoire Naturelle, Paris, France. 232 pp.

Tabuti, J.R.S., Kukunda, C.B. & Waako, P.J., 2010. Medicinal plants used by traditional medicine practitioners in the treatment of tuberculosis and related ailments in Uganda. Journal of Ethnopharmacology 127(1): 130–136.

Tabuti, J.R.S., Lye, K.A. & Dhillion, S.S., 2003. Traditional herbal drugs of Bulamogi, Uganda: plants, use and administration. Journal of Ethnopharmacology 88: 19–44.

Tabuti, J.R.S., Muwanika, V.B., Arinaitwe, M.Z. & Ticktin, T., 2011. Conservation of priority woody species on farmlands: a case study from Nawaikoke sub-county, Uganda. Applied Geography 31(2): 456–462.

Tackie, A.N. & Thomas, A., 1968. Alkaloids of Tiliacora funifera. Planta Medica 16(2): 158–165.

Tackie, A.N., Reighard, J.B., El-Azizi, M.M., Slatkin, D.J., Schiff, P.L. Jr. & Knapp, J.E., 1980. Constituents of West African medicinal plants. Part 24. Isolation of funiferine dimethiodide and oblongine from Tiliacora funifera. Phytochemistry 19(8): 1882–1883.

Tahara, S. & Ingham, J.L., 2000. Simple flavones possessing complex biological activity. Studies in Natural Products Chemistry 22(3): 457–505.

Taïta, P., 2003. Use of woody plants by locals in Mare aux Hippopotames Biosphere Reserve in western Burkina Faso. Biodiversity and Conservation 12: 1205–1217.

Takahashi, A., 1978. Compilation of data on the mechanical properties of foreign woods (part 3) Africa. Shimane University, Matsue, Japan. 248 pp.

Takawira-Nyenya, R., 2006. A taxonomic study of the genus Sansevieria (Dracaenaceae) in Zimbabwe. In: Ghazanfar, S.A. & Beentje, H.J. (Editors). Taxonomy and ecology of African plants, their conservation and sustainable use. Proceedings of the 17th AETFAT Congress, Addis Ababa, Ethiopia. Royal Botanic Gardens Kew, Richmond, United Kingdom. pp. 61–71.

Takeda, J., 1990. The dietary repertory of the Ngandu people of the tropical rain forest: an ecological and anthropological study of the subsistence activities and food procurement technology of a slash-and-burn agriculturist in the Zaire river basin. African Study Monographs, Supplement 11: 1–75.

Takeda, J., 1996. The Ngandu as hunters in the Zaïre River Basin. African Study Monographs, Supplement 23: 1–61.

Tan, B.C., 2003. Sphagnum L. In: de Winter, W.P. & Amoroso, V.B. (Editors). Plant Resources of South-East Asia No 15(2): Cryptogams: Ferns and fern allies. Backhuys Publishers, Leiden, Netherlands. pp. 197–199.

Tandon, P., Abrol, Y.P. & Kumaria, S. (Editors), 2007. Biodiversity and its significance. I.K. International, New Delhi, India. 370 pp.

Tanno, T., 1981. Plant utilization of the Mbuti Pygmies - with special reference to their material culture and use of wild vegetable foods. African Study Monographs 1: 1–53.

Tchatat, M., 1999. Produits forestiers autres que le bois d'oeuvre (PFAB) : place dans l'aménagement durable des forêts denses humides d'Afrique Centrale. Document Forafri 18. Cirad, Montpellier, France. 94 pp.

Tefera, S., Dlamini, B.J. & Dlamini, A.M., 2010. Changes in soil characteristics and grass layer condition in relation to land management systems in the semi-arid savannas of Swaziland. Journal of Arid Environments 74: 675–684.

Tehe, H., 1986. Utilisations des ressources forestiers chez les Guérés et les Oubis (Côte d'Ivoire). Banco 4: 26–30.

Teketay, D., 1993. Problems associated with raising trees from seeds. The Ethiopian experience. In: Lieth, H. & Lohmann, M. (Editors). Restoration of tropical forest ecosystems. Proceedings of the Symposium held on October 7–10, 1991. Kluwer Academic Publishers, Dordrecht, Netherlands. pp. 91–100.

Teketay, D. & Granström, A., 1997. Germination ecology of forest species from the highlands of Ethiopia. Journal of Tropical Ecology 13(6): 805–831.

Teklehaymanot, T., 2009. Ethnobotanical study of knowledge and medicinal plants use by the people in Dek Island in Ethiopia. Journal of Ethnopharmacology 124(1): 69–78.

Teklehaymanot, T. & Giday, M., 2007. Ethnobotanical study of medicinal plants used by people in Zegie Peninsula, Northwestern Ethiopia. Journal of Ethnobiology and Ethnomedicine 3: 12.

Temu, R.-A.P.C., 1990. Taxonomy and biogeography of woody plants in the Eastern Arc Mts, Tanzania: case studies in Zenkerella, Scorodophloeus and Peddiea. Acta Universitatis Upsaliensis 286. Upsala University, Uppsala, Sweden. 68 pp.

Temu, A. & Due, J. M., 1998. The success of newly privatized companies: new evidence from Tanzania. Canadian Journal of Development Studies 19: 315–341.

Tenati, G., 2003. The use of rattan for vocational rehabilitation in Zambia. In: Sunderland, T.C.H. & Profizi, J.P. (Editors). New research on African rattans. Proceedings of the CARPE funded International Expert Meeting on the Rattans of Africa, held at the Limbe Botanic Garden, Cameroon, 1–3 February 2000. International Network for Bamboo and Rattan (INBAR), Beijing, China. pp 97–104.

Terashima, H. & Ichikawa, M., 2003. A comparative ethnobotany of the Mbuti and Efe hunter-gatherers in the Ituri forest, Democratic Republic of Congo. African Study Monographs 24(1–2): 1–168.

Terashima, H., Ichikawa, M. & Sawada, M., 1988. Wild plant utilization of the Balese and the Efe of the Ituri Forest, the Republic of Zaire. African Study Monographs, Supplement 8. The Center for African Area Studies, Kyoto University, Kyoto, Japan. 78 pp.

Terashima, H., Kalala, S. & Malasi, N., 1991. Ethnobotany of the Lega in the tropical rain forest of eastern Zaire: part one, zone de Mwenga. African Study Monographs, Supplement 15: 1–61.

Terashima, H., Kalala, S. & Malasi, N., 1992. Ethnobotany of the Lega in the tropical rain forest of Eastern Zaire: part two, zone de Walikale. African Study Monographs, Supplement 19: 1–60.

Téré, H.G., 2000. Signification des noms vernaculaires des plantes chez les Guérés (Côte d'Ivoire). Sempervira No 7. Centre Suisse de Recherches Scientifiques (CSRS), Abidjan, Côte d'Ivoire. 96 pp.

Termote, C., Van Damme, P. & Dhed'a Djailo, B., 2010. Eating from the wild: Turumbu indigenous knowledge on noncultivated edible plants, Tshopo District, DR Congo. Ecology of Food and Nutrition 49(3): 173–207.

Terry, P.J., Adjers, G., Akobundu, I.O., Anoka, A.U., Drilling, M.E., Tjitrosemito, S. & Utomo, M., 1997. Herbicides and mechanical control of Imperata cylindrica as a first step in grassland rehabilitation. Agroforestry Systems 36: 151–179.

Tewksbury, L., Casagrande, R., Blossey, B., Häfliger, P. & Schwarzländer, M., 2002. Potential for Biological Control of Phragmites australis in North America. Biological Control 23: 191–212.

Thakur, R.N., Pandotra, V.R. & Sastry, K.S.M., 1977. Stem burn - a new disease of Hibiscus sabdariffa from India (Phytophthora nicotianae var. nicotianae). Indian Phytopathology 29: 322–323.

Thiel, J. & Bedel, J., 1973. Essai de résistance naturelle de bois à Madagascar: premier rapport. Centre Technique Forestier Tropical, Antananarivo, Madagascar. 74 pp.

Thiombiano, A., Wittig, R. & Guinko, S., 2003. Conditions de la multiplication sexuée chez des Combretaceae du Burkina Faso. Revue d'Ecologie 58(4): 361–379.

Thomas, J., 1959. Notes d'ethnobotanique africaine : plantes utilisées dans la région de la Lobaye (Afrique Centrale). Journal d'Agriculture Tropicale et de Botanique Appliquée 6(8–9): 353–390.

Thomas, J.E., 2000. Viruses of banana and methods for their detection. In: Molina, A.B., Roa, V.N., Bay-Petersen, J., Carpio, A.T. & Joven, J.E.A. (Editors). Managing banana and citrus diseases. Proceedings of a regional workshop on disease management of banana and citrus through the use of disease-free planting materials held in Davao City, Philippines, 14–16 October 1998. International Network for the Improvement of Banana and Plantain – Asia and the Pacific Network (INIBAP–ASPNET), Los Baños, the Philippines. pp. 32–37.

Thomas, J.M., Bahuchet, S. & Epelboin, A. (Editors), 1998. Encyclopédie des Pygmées Aka II. Dictionnaire ethnographique Aka-Français, fascicule 4: T–D. Peeters, Paris, France. 246 pp.

Thomas, D.W., Thomas-Mc Cauley, J., Bromley, W.A. & Mbenkum, F.T., 1989. Korup ethnobotany survey. World Wildlife Fund, Godalming, United Kingdom. 108 + 35 pp.

Thornell, C., 2005. Des plantes à l'état sauvage chez le peuple Mpiemo: leurs noms et leurs usages. Göteborg Africana Informal Series No 5. Department of Oriental and African Languages, University of Gothenburg, Sweden. 99 pp.

Thulin, M., 1989. Fabaceae (Leguminosae). In: Hedberg, I. & Edwards, S. (Editors). Flora of Ethiopia. Volume 3. Pittosporaceae to Araliaceae. The National Herbarium, Addis Ababa University, Addis Ababa, Ethiopia and Department of Systematic Botany, Uppsala University, Uppsala, Sweden. pp. 49–251.

Thulin, M., 1993. Combretaceae. In: Thulin, M. (Editor). Flora of Somalia. Volume 1. Pteridophyta; Gymnospermae; Angiospermae (Annonaceae-Fabaceae). Royal Botanic Gardens, Kew, Richmond, United Kingdom. pp. 247–254.

Thulin, M., 1995a. Arecaceae (Palmae). In: Thulin, M. (Editor). Flora of Somalia. Volume 4. Angiospermae (Hydrocharitaceae-Pandanaceae). Royal Botanic Gardens, Kew, Richmond, United Kingdom. pp. 270–274.

Thulin, M., 1995b. Dracaenaceae. In: Thulin, M. (Editor). Flora of Somalia. Volume 4. Angiospermae (Hydrocharitaceae-Pandanaceae). Royal Botanic Gardens, Kew, Richmond, United Kingdom. pp. 27–30.

Thulin, M., 1995c. Pandanaceae. In: Thulin, M. (Editor). Flora of Somalia. Volume 4. Angiospermae (Hydrocharitaceae-Pandanaceae). Royal Botanic Gardens, Kew, Richmond, United Kingdom. pp. 274–275.

Thulin, M., 1999a. Malvaceae. In: Thulin, M. (Editor). Flora of Somalia. Volume 2. Angiospermae (Tiliaceae-Apiaceae). Royal Botanic Gardens, Kew, Richmond, United Kingdom. pp. 40–83.

Thulin, M., 1999b. Sterculiaceae. In: Thulin, M. (Editor). Flora of Somalia. Volume 2. Angiospermae (Tiliaceae-Apiaceae). Royal Botanic Gardens, Kew, Richmond, United Kingdom. pp. 21–37.

Thulin, M., 1999c. Vitaceae. In: Thulin, M. (Editor). Flora of Somalia. Volume 2. Angiospermae (Tiliaceae-Apiaceae). Royal Botanic Gardens, Kew, Richmond, United Kingdom. pp. 156–168.

Tida, M.M., 1997. Contribution à l'inventaire forestier et à l'étude de la flore médicinale des relictes forestières de Tsinjoarivo. Mémoire de DEA Ecologie Végétale Faculté des Sciences, Université d'Antananarivo, Madagascar. 39 pp.

Tijani, A.Y., Okhale, S.E., Oga, F.E., Tags, S.Z., Salawu, O.A. & Chindo, B.A., 2008. Anti-emetic activity of Grewia lasiodiscus root extract and fractions. African Journal of Biotechnology 7(17): 3011–3016.

Timber Research Unit, 2007. Tasmanian oak: Eucalyptus delegatensis, E. obliqua & E. regnans. [Internet] Tasmanian Timber Promotion Board. <http://www.tastimber.tas.gov.au/ species/pdfs/TasoakV4.pdf>. Accessed May 2009.

Timberlake, J., Fagg, C. & Barnes, R., 1999. Field guide to the Acacias of Zimbabwe. CBC Publishing, Harare, Zimbabwe. 160 pp.

Tindale, M.D. & Roy, S.K., 2002. A cytotaxonomic survey of the Pteridophyta of Australia. Australian Systematic Botany 15: 839–937.

Titanji, V.P.K., Ayafor, J.F., Mulufi, J.P. & Mbacham, W.F., 1987. In vitro killing of Onchocerca volvulus (Filaroidea) adults and microfilariae by selected Cameroonian medicinal plant extracts. Fitoterapia 58(5): 338–339.

Titien Ngatinem Praptosuwiryo, 2003. Dicranopteris linearis (Burm.f.) Underw. In: de Winter, W.P. & Amoroso, V.B. (Editors). Plant Resources of South-East Asia No 15(2): Cryptogams: Ferns and fern allies. Backhuys Publishers, Leiden, Netherlands. pp. 93–96.

Tobler, M.W., Cochard, R. & Edwards, P.J., 2003. The impact of cattle ranching on large-scale vegetation patterns in a coastal savanna in Tanzania. Journal of Applied Ecology 40(3): 430–444.

Toirambe Bamoninga, B., 2007. Analyse de l'état des lieux du secteur des produits forestiers non ligneux et évaluation de leur contribution à la sécurité alimentaire en République Démocratique du Congo. Projet GCP/RAF/398/GER, Renforcement de la sécurité alimentaire en Afrique Centrale à travers la gestion et l'utilisation durable des Produits Forestiers Non Ligneux. 76 pp.

Toledo-Aceves, T. & Swaine, M.D., 2007. Effect of three species of climber on the performance of Ceiba pentandra seedlings in gaps in a tropical forest in Ghana. Journal of Tropical Ecology 23(1): 45–52.

Toledo-Aceves, T. & Swaine, M.D., 2008a. Above- and below-ground competition between the liana Acacia kamerunensis and tree seedlings in contrasting light environments. Plant Ecology 196(2): 233–244.

Toledo-Aceves, T. & Swaine, M.D., 2008b. Effect of lianas on tree regeneration in gaps and forest understorey in a tropical forest in Ghana. Journal of Vegetation Science 19(5): 717–728.

Tomlinson, P.B., 1961. Morphological and anatomical characteristics of the Marantaceae. Journal of the Linnean Society of London, Botany 58(370): 55–78.

Tönsjost, S., 2007. Plants and pastures. Local knowledge on livestock-environment relationships among OvaHerero pastoralists in north-western Namibia. Kölner Ethnologische Beiträge. Heft 23. Institut für Ethnologie, Universität zu Köln, Cologne, Germany. 91 pp.

Tothill, J.C., 1966. Phenological variation in Heteropogon contortus and its relation to climate. Australian Journal of Botany 14(1): 35–47.

Tothill, J.C., 1968. Variation and apomixis in Heteropogon contortus, Gramineae. Boletin de la Sociedad Argentina de Botanica 12: 188–201.

Tothill, J.C., 1992. Heteropogon contortus (L.) P. Beauv. ex Roemer & Schultes. In: 't Mannetje, L. & Jones, R.M. (Editors). Plant Resources of South-East Asia No 4. Forages. Pudoc Scientific Publishers, Wageningen, Netherlands. pp. 137–139.

Tothill, J.C. & Hacker, J.B., 2006. Polyploidy, flowering phenology and climatic adaptation in Heteropogon contortus (Gramineae). Austral Ecology 1(4): 213–222.

Tothill, J.C., Nix, H.A., Stanton, J.P. & Russell, M.J., 1985. Land use and productive potentials of Australian savanna lands. In: Tothill, J.C. & Mott, J.J. (Editors): The ecology and management of the world's savannas. Australian Academy of Science, Canberra, Australia. pp. 125–144.

Toutain, B., 1980. The role of browse plants in animal production in the Sudanian zone of West Africa. In: Le Houérou, H.N. (Editor). Browse in Africa: the current state of knowledge. Papers presented at the International Symposium on Browse in Africa, Addis Ababa, April 8–12, 1980, and other submissions. International Livestock Centre for Africa, Addis Ababa, Ethiopia. pp. 103–108.

Touzeau, J., 1973. Les arbres fourragers de la zone sahélienne de l'Afrique. Thèse Doct. Vétérinaire, Université Paul Sabatier, Toulouse, 125 pp.

Townson, I.M., 1995. Incomes from non-timber forest products. Patterns of enterprise activity in the forest zone of southern Ghana. Main Report. Oxford Forestry Institute, Oxford, United Kingdom. 127 pp.

Tra Bi, F.H., 1997. Utilisations des plantes, par l'homme, dans les forêts classées du Haut-Sassandra et de Scio, en Côte d'Ivoire. Thèse pour obtenir le Doctorat de troisième cycle, Faculté des Sciences et Techniques, Université de Cocody, Abidjan, Côte d'Ivoire. 215 pp.

Tra Bi, F.H., Kouamé, F.N. & Traoré, D., 2005. Utilisation of climbers in two forest reserves in West Côte d'Ivoire. In: Bongers, F., Parren, M.P.E. & Traoré, D. (Editors). Forest climbing plants of West Africa. Diversity, ecology and management. CABI Publishing, Wallingford, United Kingdom. pp. 167–181.

Tra Bi, F.H., Kouamé, N.F., Traoré, D. & van der Maesen, L.J.G., 1999. Les lianes dans l'entretien bucco-dentaire en Côte d'Ivoire. Revue de Médecines et Pharmacopées Africaines 13: 65–70.

Traoré, H., Yonli, D., Zomboudré, G., Dabré, M. & Lingani, P., 1998. Perception paysanne du problème du Striga et inventaire des méthodes endogènes de lutte dans l'est du Burkina Faso. In: Ministère des Enseignements Secondaire, Supérieur et de la Recherche Scientifique/ Centre National de la Recherche Scientifique et Technologique (Editeurs). Recherche scientifique et développement durable. Actes 3e édition du Forum National de la Recherche Scientifique et des Innovations Technologiques (FRSIT), avril 1998. Ouagadougou, Burkina Faso. Tome 2: Les communications. pp. 378–386.

Traynor, C.H., 2008. Juncus kraussii harvesting in Umlalazi Nature Reserve, KwaZulu-Natal, South Africa: socio-economic aspects and sustainability. African Journal of Aquatic Science 33(1): 27–36.

Traynor, C.H., Kotze, D.C. & Mckean, S.G., 2010. Wetland craft plants in KwaZulu-Natal: an ecological review of harvesting impacts and implications for sustainable utilization. Bothalia 40(1): 135–144.

Troupin, G., 1949. Contribution a l'étude des Menispermacées africaines. I. Bulletin du Jardin Botanique de l'Etat (Bruxelles) 19(4): 409–435.

Troupin, G., 1951. Menispermaceae. In: Robyns, W., Staner, P., Demaret, F., Germain, R., Gilbert, G., Hauman, L., Homès, M., Jurion, F., Lebrun, J., Vanden Abeele, M. & Boutique, R. (Editors). Flore du Congo belge et du Ruanda-Urundi. Spermatophytes. Volume 2. Institut National pour l'Étude Agronomique du Congo belge, Brussels, Belgium. pp. 202–255.

Troupin, G., 1960. Menispermaceae. In: Exell, A.W. & Wild, H. (Editors). Flora Zambesiaca. Volume 1, part 1. Crown Agents for Oversea Governments and Administrations, London, United Kingdom. pp. 150–171.

Tshiamala-Tshibangu, N., Gbeli, Essimbi, E.P. & Ndjigba, J.D., 1999. Utilisation des produits forestiers autres que le bois (PFAB) au Cameroun : cas du projet forestier du Mont Koupé. Revue de Médecines et Pharmacopées Africaines 13: 19–32.

Tucker, G.C., 2003. Cladium. [Internet] In: Ball, P.W., Reznicek, A.A. & Murray, D.F. (Editors). Flora of North America Vol. 23. pp. 240–242. <http://www.efloras.org/ florataxon.aspx?flora_id=1&taxon_id=107172>. Accessed February 2011.

Tuffour, K., 1997. The role of plant genetic resources in crop and forest improvement: forest genetic resources in Ghana and their potential for improvement. In: Bennet-Lartey, S.O., Akromah, R. & Gamedoagbao, D. (Editors). Biodiversity and plant genetic resources in Ghana. Proceedings of First national workshop, November 21–24, 1994, Koforidua, Ghana. pp. 21–33.

Tuley, P., 1994. African bass/piassava – a historical perspective. Principes 38(1): 36–46.

Tuley, P., 1995. The palms of Africa. The Trendrine Press, St. Ives, United Kingdom. 189 pp.

Turpie, J.K., 2000. The use and value of natural resources of the Rufiji floodplain and delta, Tanzania. Technical report No 17. Rufiji Environment Management Project, Dar es Salaam, Tanzania. 87 pp.

Tushemereirwe, W.K. & Bagabe, M., 1999. Review of disease distribution and pest status in Africa. In: Frison, E.A., Gold, C.S., Karamura, E.B. & Sikora, R.A. (Editors). Mobilizing IPM for sustainable banana production in Africa. Proceedings of a workshop on banana IPM held in Nelspruit, South Africa, 23–28 November 1998. INIBAP, Montpellier, France. pp. 139–147.

Tyler-Walters, H., 2002. Common reed, Phragmites australis. [Internet] Marine Life Information Network, Plymouth, UK. <http://www.marlin.ac.uk/ speciesinformation.php?speciesID=4753>. Accessed December 2010.

Uche, F.I. & Ezugwu, C.O., 2009. Evaluation of antioxidant activities of some Nigerian medicinal plants. Asian Pacific Journal of Tropical Medicine 2(4): 27–32.

Uche, F.I. & Okunna, B.U., 2009. Phytochemical constituents, analgesic and anti-inflammatory effects of methanol extract of Triumfetta rhomboidea leaves in animal models. Asian Pacific Journal of Tropical Medicine 2(5): 26–29.

Uchiyama, H., Matoba, H., Aizawa, T., Sumida, H. & Do Minh Nhut, 2010. Chromosome counts of some wetland Cyperaceous species from the Mekong Delta, Vietnam. Cytologia 75(4): 335–339.

Uchytil, R.J., 1992a. Cladium jamaicense. [Internet] In: Fire Effects Information System, Rocky Mountain Research Station, Fire Sciences Laboratory, Missoula, Montana, United States. <http://www.fs.fed.us/ database/feis/plants/graminoid/clajam/ all.html>. Accessed August 2009.

Uchytil, R.J., 1992b. Phragmites australis. [Internet] In: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory, Fire Effects Information System. <http://www.fs.fed.us/ database/feis/plants/graminoid/phraus/ all.html>19 p. Accessed December 2010.

Ugborogho, R.E., 1983. Evolution of Sida L. (Malvaceae) in West Africa. Bulletin du Muséum National d'Histoire Naturelle, Paris, séries 4, 5, section B, Adansonia 1: 93–102.

Uhl, N.W. & Dransfield, J., 1987. Genera palmarum - a classification of palms based on the work of Harold E. Moore Jr. The L.H. Bailey Hortorium and the International Palm Society. Allen Press, Lawrence KS, United States. 610 pp.

Umerie, S.C., Ogbuagu, A.S. & Ogbuagu, J.O., 2004. Stabilization of palm oils by using Ficus exasperata leaves in local processing methods. Bioresource Technology 94(3): 307–310.

Umi Kalsom Yusuf, 1995. The taxonomic significance of leaf flavonoids in west Malaysian Dicranopteris taxa (Gleicheniaceae). Blumea 40: 211–215.

Undang A. Dasuki, 2001. Hibiscus L. In: van Valkenburg, J.L.C.H. & Bunyapraphatsara, N. (Editors). Plant Resources of South-East Asia No 12(2): Medicinal and poisonous plants 2. Backhuys Publishers, Leiden, Netherlands. pp. 297–303.

UNIDO & CFC, 2005. Product and market development of sisal and henequen. Project completion report. Kenya–Tanzania, January 1997–December 2005. United Nations Industrial Development Organization, Vienna, Austria. 54 pp.

Unruh, B.L. & Silvertooth, J.C., 1996. Comparison between an Upland and Pima cotton cultivar: I. Growth and yield. Agronomy Journal 88: 583–589.

Unwin, A.H., 1920. West African forests and forestry. [Internet] T. Fisher Unwin Ltd, London, United Kingdom. 527 pp. <http://www.archive.org/ details /westafricanfores00unwi>. Accessed February 2010.

Uprety, Y., Asselin, H., Boon, E.K., Yadav, S. & Shrestha, K.K., 2010. Indigenous use and bio-efficacy of medicinal plants in the Rasuwa District, Central Nepal. Journal of Ethnobiology and Ethnomedicine 6: 3.

Urquhart, R., 1997. Paleoecological evidence of Raphia in the Pre-Columbian Neotropics. Journal of Tropical Ecology13: 783–792.

USDA, 2004. USDA national nutrient database for standard reference, release 17. [Internet] U.S. Department of Agriculture, Agricultural Research Service, Nutrient Data Laboratory, Beltsville Md, United States. <http://www.nal.usda.gov/fnic/foodcomp>. Accessed July 2005.

USDA Forest Service, undated. Wood technical fact sheet Julbernardia globiflora. [Internet] USDA Forest Service, Forest Products Laboratory, Madison, Wisconsin, United States. <http://www.fpl.fs.fed.us/ documnts/TechSheets/Chudnoff/African/htmlDocs_africa/ Julbernardiaglobiflora.htm>. Accessed March 2010.

USDA, ARS & National Genetic Resources Program, 2001. Germplasm Resources Information Network - (GRIN). [Internet] National Germplasm Resources Laboratory, Beltsville, Maryland, United States. <http://www.ars-grin.gov/>. Accessed October 2009.

USDA, ARS & National Genetic Resources Program, 2011. Germplasm Resources Information Network - (GRIN). [Internet] National Germplasm Resources Laboratory, Beltsville, Maryland, United States. <http://www.ars-grin.gov/>. Accessed January 2011.

USDA, NRCS, 2009. Cladium mariscus ssp. jamaicense. [Internet] In: The PLANTS Database, National Plant Data Center, Baton Rouge, Louisiana, United States. <http://plants.usda.gov/ java/profile?symbol=CLMAJ>. Accessed August 2009.

Vainio-Mattila, K., 2000. Wild vegetables used by the Sambaa in the Usambara Mountains, NE Tanzania. Annales Botanici Fennici 37: 57–67.

Valenza, J. & Fayolle, F., 1965. Note sur les essais de charge de pâturage en République du Sénégal. Revue d'Elevage et de Médecine Vétérinaire des Pays Tropicaux 18(3): 321–327.

van Borssum-Waalkes, J., 1966. Malesian Malvaceae revised. Blumea 14: 1–251.

van Dam, A.A., Dardona, A., Kelderman, P. & Kansiime, F., 2007. A simulation model for nitrogen retention in a papyrus wetland near Lake Victoria, Uganda (East Africa). Wetlands Ecology and Management 15: 469–480.

Van Damme, P. & Termote, C., 2008. African botanical heritage for new crop development. Afrika focus 21(1): 45–64.

van den Bout van den Beukel, C.J., Hamza, O.J., Moshi, M.J., Matee, M.I., Mikx, F., Burger, D.M., Koopmans, P.P., Verweij, P.E., Schoonen, W.G. & van der Ven, A.J., 2008. Evaluation of cytotoxic, genotoxic and CYP450 enzymatic competition effects of Tanzanian plant extracts traditionally used for treatment of fungal infections. Basic & Clinical Pharmacology & Toxicology 102(6): 515–526.

Van den Eynden, V., Van Damme, P. & de Wolf, J., 1994. Inventaire et modelage de la gestion du couvert végétal pérenne dans une zone forestière du sud du Sénégal. Rapport final, Partie C: Etude ethnobotanique. University of Gent, Gent, Belgium. 111 pp.

Van den Eynden, V., Vernemmen, P. & Van Damme, P., 1992. The ethnobotany of the Topnaar. University of Gent, Belgium. 145 pp.

van der Maesen, L.J.G., 2001. Entada Adanson. In: van Valkenburg, J.L.C.H. & Bunyapraphatsara, N. (Editors). Plant Resources of South-East Asia No 12(2): Medicinal and poisonous plants 2. Backhuys Publishers, Leiden, Netherlands. pp. 246–248.

Van der Veen, L.J. & Bodinga bwa Bodinga, S., undated. Une société traditionnelle noire africaine et ses plantes utiles : les Éviya du Gabon. Dénomination, catégorisation et utilisation des plantes. [Internet] Editions Raponda-Walker, Libreville, Gabon. 140 pp. <http://www.ddl.ish-lyon.cnrs.fr/fulltext/Van%20der%20Veen/ Van%20der%20Veen_%C3%A0%20para%C3%AEtre_a.pdf>. Accessed May 2009 - January 2011.

van der Walt, J.J.A., 1986. Burseraceae. In: Leistner, O.A. (Editor). Flora of southern Africa. Volume 18, part 3. Botanical Research Institute, Department of Agriculture and Water Supply, Pretoria, South Africa. pp. 5–34.

van der Walt, L., 2000. Dais cotinifolia L. [Internet] South African National Biodiversity Institute, Kirstenbosch, South Africa. <http://www.plantzafrica.com/ plantcd/ daiscotonifolia.htm>. Accessed February 2009.

van der Zon, A.P.M., 1992. Graminées du Cameroun. Volume 2, Flore. Wageningen Agricultural University Papers 92–1. Wageningen Agricultural University, Wageningen, Netherlands. 557 pp.

van der Zon, A.P.M. & Grubben, G.J.H., 1976. Les légumes-feuilles spontanés et cultivés du Sud-Dahomey. Communication 65. Département des Recherches Agronomiques, Koninklijk Instituut voor de Tropen, Amsterdam, Netherlands. 111 pp.

van Dijk, J.F.W., 1997. An assessment of non-wood forest product resources for the development of sustainable commercial extraction. In: Sunderland, T.C.H., Clark, L.E. & Vantomme, P. (Editors). Non-wood forest products of Central Africa: current research issues and prospects for conservation and development. FAO, Rome, Italy. pp. 37–49.

van Epenhuijsen, C.W., 1974. Growing native vegetables in Nigeria. FAO, Rome, Italy. 113 pp.

Van Loan, A.N., Meeker, J.R. & Minno, M.C., 2002. 28. Cogon grass. In: Van Driesche, R., Blossey, B., Hoddle, M., Lyon, S. & Reardon, R. (Editors). Biological control of invasive plants in the eastern United States. Forest Health Technology Enterprise Team, Morgantown, United States. pp. 361–372.

van Noort, S. & Rasplus, J.Y., 2007. Figs and fig wasps. [Internet] <http://www.figweb.org/Figs_and_fig_wasps/ index.htm>. Accessed July 2009.

van Noort, S., Gardiner, A.J. & Tolley, K.A., 2007. New records of Ficus (Moraceae) species emphasize the conservation significance of inselbergs in Mozambique. South African Journal of Botany 73(4): 642–649.

van Oijen, M., Dauzat, J., Harmand, J.-M., Lawson, G. & Vaast, P., 2010. Coffee agroforestry systems in Central America. I. A review of quantitative information on physiological and ecological processes. Agroforestry Systems 80(3): 341–359.

van Oudtshoorn, F., 1999. Guide to grasses of Southern Africa. Briza Publications, Pretoria, South Africa. 288 pp.

van Rensburg, H.J., 1968. Growth and seasonal composition of natural grassland in Zambia. Grass and Forage Science 23(1): 51–52.

Van Rooyen, M.W., Tosh, C.A., van Rooyen, N., Matthews, W.S. & Kellerman, M.J.S., 2004. Impact of harvesting and fire on Phragmites australis reed quality in Tembe Elephant Park, Maputaland. Koedoe 47(1): 31–40.

van Valkenburg, J.L.C.H., 2001. Laportea Gaudich. In: van Valkenburg, J.L.C.H. & Bunyapraphatsara, N. (Editors). Plant Resources of South-East Asia No 12(2): Medicinal and poisonous plants 2. Backhuys Publishers, Leiden, Netherlands. pp. 324–327.

van Valkenburg, J.L.C.H. & Sunderland, T.C.H., 2008. A revision of the genus Podococcus (Arecaceae). Kew Bulletin 63(2): 251–260.

van Valkenburg, J.L.C.H., Sunderland, T.C.H. & Couvreur, T.L.P., 2008. A revision of the genus Sclerosperma (Arecaceae). Kew Bulletin 63: 75–86.

van Valkenburg, J., Sunderland, T., Ngok Banak, L. & Issembé, Y., 2007. Sclerosperma and Podococcus in Gabon. Palms 51(2): 77–83.

van Wyk, B.E. & Gericke, N., 2000. People's plants: a guide to useful plants of southern Africa. Briza Publications, Pretoria, South Africa. 351 pp.

van Wyk, B. & van Wyk, P., 1997. Field guide to trees of southern Africa. Struik Publishers, Cape Town, South Africa. 536 pp.

van Wyk, B. & van Wyk, P., 2007. How to identify trees in southern Africa. Struik Publishers, Cape Town, South Africa. 184 pp.

van Wyk, B.E., van Heerden, F. & van Oudtshoorn, B., 2002. Poisonous plants of South Africa. Briza Publications, Pretoria, South Africa. 288 pp.

van Wyk, B.E., van Oudtshoorn, B. & Gericke, N., 1997. Medicinal plants of South Africa. Briza Publications, Pretoria, South Africa. 304 pp.

Vanden Berghen, C., 1988. Flore illustrée du Sénégal. Monocotylédones et Ptéridophytes. Volume 9. Monocotylédones: Agavacées à Orchidacées. Gouvernement du Sénégal, Ministère du Développement Rural et de l'Hydraulique, Direction des Eaux et Forêts, Dakar, Senegal. 522 pp.

Vánky, K., 2000. Taxonomical studies on Ustilaginales. XX. Mycotaxon 74(1): 161–215.

Vánky, K., 2003. The smut fungi (Ustilaginomycetes) of Hyparrhenia (Poaceae). Fungal Diversity 12: 179–205.

Vaughan, R.E. & Wiehe, P.O., 1953. The genus Pandanus in the Mascarene Islands. Journal of the Linnean Society – Botany 55: 1–32.

Vawdrey, L.L. & Stirling, G.R., 1992. Reaction of kenaf and roselle grown in the Burdekin River irrigation area to root-knot nematodes. Australasian Plant Pathology 21(1): 8–12.

Velayos, M., Aedo, C., Cabezas, F., de la Estrella, M., Fero, M. & Barberá, P., 2010. Flora de Guinea ecuatorial: claves de plantas vasculares de Annobón, Bioko y Río Muni. Volume 5. Leguminosae. Consejo Superior de Investigaciones Científicas. Real Jardín Botánico, Madrid, Spain. 529 pp.

Venter, F. & Venter, J.-A., 1996. Making the most of indigenous trees. Briza publications, Capetown, South Africa. 304 pp.

Venter, H.J.T. & Verhoeven, R.L., 1997. A tribal classification of the Periplocoideae (Apocynaceae). Taxon 46(4): 705–720.

Verdcourt, B., 1993. Vitaceae. In: Polhill, R.M. (Editor). Flora of Tropical East Africa. A.A. Balkema, Rotterdam, Netherlands. 149 pp.

Verdcourt, B., 2000. Gleicheniaceae. In: Beentje, H.J. (Editor). Flora of Tropical East Africa. A.A. Balkema, Rotterdam, Netherlands. 11 pp.

Verdcourt, B., 2001. Myrtaceae. In: Beentje, H.J. (Editor). Flora of Tropical East Africa. A.A. Balkema, Rotterdam, Netherlands. 89 pp.

Verdcourt, B., 2004. The variation of Sida rhombifolia L. (Malvaceae) in East Africa. Kew Bulletin 59(2): 233–239.

Verdcourt, B., 2006. Thelypteridaceae. In: Beentje, H.J. & Ghazanfar, S.A. (Editors). Flora of Tropical East Africa. Royal Botanic Gardens, Kew, Richmond, United Kingdom. 44 pp.

Verdcourt, B. & Mwachala, G.M., 2009. Malvaceae. In: Beentje, H.J. & Ghazanfar, S.A. (Editors). Flora of Tropical East Africa. Royal Botanic Gardens, Kew, Richmond, United Kingdom. 169 pp.

Verger, P.F., 1995. Ewé: The use of plants in Yoruba society. Editoria Schwarcz, Sao Paulo, Brazil. 744 pp.

Vergiat, A.M., 1970a. Plantes magiques et médicinales des féticheurs de l'Oubangui (Région de Bangui). (Fin). Journal d'Agriculture Tropicale et de Botanique Appliquée 17: 295–339.

Vergiat, A.M., 1970b. Plantes magiques et médicinales des féticheurs de l'Oubangui (Région de Bangui). (Suite). Journal d'Agriculture Tropicale et de Botanique Appliquée 17(1–4): 60–91.

Ververis, C., Georghiou, K., Christodoulakis, N., Santas, P. & Santas, R., 2004. Fiber dimensions, lignin and cellulose content of various plant materials and their suitability for paper production. Industrial Crops and Products 19: 245–254.

Viguier, R., 1984. Leguminosae madagascarienses novae. Notulae Systematicae (Paris) 13: 333–369.
Villiers, J.-F., 1973. Bombacaceae. Flore du Gabon. Volume 22. Muséum National d'Histoire Naturelle, Paris, France. pp. 31–54.
Villiers, J.-F., 1975. Bombacaceae. Flore du Cameroun. Volume 19. Muséum National d'Histoire Naturelle, Paris, France. pp. 71–98.
Villiers, J.-F., 1986. Flagellariaceae. Flore du Gabon. Volume 28. Muséum National d'Histoire Naturelle, Paris, France. pp. 55–60.
Villiers, J.-F., 1989. Leguminosae - Mimosoideae. Flore du Gabon. Volume 31. Muséum National d'Histoire Naturelle, Paris, France. 185 pp.
Vincent, C.P. & Kanna, R.R., undated. Anti bacterial activity of ferns – Christilla parasitica and Cyclosorus interuptus against Salmonella typhi. [Internet] Center of Biodiversity and Biotechnology, St. Xavier's College, Palayamkottai, Tamilnadu, India. <http://openmed.nic.in/ 2009/01/ferns.pdf>. Accessed February 2010.
Visser, L.E., 1975. Plantes médicinales de la Côte d'Ivoire. Mededelingen Landbouwhogeschool Wageningen 75–15, Wageningen, Netherlands. 79 pp.
Vivien, J., 1990. Fruitiers sauvages du Cameroun. Fruits Paris 45(2): 149–160.
Vivien, J. & Faure, J.J., 1988. Fruitiers sauvages du Cameroun. Fruits Paris 43(9): 507–516.
Vivien, J. & Faure, J.J., 1996. Fruitiers sauvages d'Afrique: espèces du Cameroun. Ministère Français de la Coopération, Paris, France & CTA, Wageningen, Netherlands. 416 pp.
Vlietinck, A.J., van Hoof, L., Totté, J., Lasure, A., Vanden Berghe, D.A., Rwangabo, P.C. & Mvukiyumwami, J., 1995. Screening of hundred Rwandese medicinal plants for antimicrobial and antiviral properties. Journal of Ethnopharmacology 46: 31–47.
Vollesen, K., 1987. The native species of Gossypium (Malvaceae) in Africa, Arabia and Pakistan. Kew Bulletin 42(2): 337–349.
Vollesen, K., 1989. Vitaceae. In: Hedberg, I. & Edwards, S. (Editors). Flora of Ethiopia. Volume 3. Pittosporaceae to Araliaceae. The National Herbarium, Addis Ababa University, Addis Ababa, Ethiopia and Department of Systematic Botany, Uppsala University, Uppsala, Sweden. pp. 399–418.
Vollesen, K., 1995a. Malvaceae. In: Edwards, S., Mesfin Tadesse & Hedberg, I. (Editors). Flora of Ethiopia and Eritrea. Volume 2, part 2. Canellaceae to Euphorbiaceae. The National Herbarium, Addis Ababa University, Addis Ababa, Ethiopia and Department of Systematic Botany, Uppsala University, Uppsala, Sweden. pp. 190–256.
Vollesen, K., 1995b. Sterculiaceae. In: Edwards, S., Mesfin Tadesse & Hedberg, I. (Editors). Flora of Ethiopia and Eritrea. Volume 2, part 2. Canellaceae to Euphorbiaceae. The National Herbarium, Addis Ababa University, Addis Ababa, Ethiopia and Department of Systematic Botany, Uppsala University, Uppsala, Sweden. pp. 165–185.
Vollesen, K. & Demissew Sebsebe, 1995. Tiliaceae. In: Edwards, S., Mesfin Tadesse & Hedberg, I. (Editors). Flora of Ethiopia and Eritrea. Volume 2, part 2. Canellaceae to Euphorbiaceae. The National Herbarium, Addis Ababa University, Addis Ababa, Ethiopia and Department of Systematic Botany, Uppsala University, Uppsala, Sweden. pp. 145–164.
Vololomboahangy, T.E.S., 2004. Attractions culturelles. In: Proposition d'un plan d'aménagement pour le développement de l'écotourisme dans les deux communes rurales d'Ambohimitombo et d'Antoetra dans la sous préfecture d'Ambositra Province autonome de Fianarantsoa. Mémoire de fin d'étude pour l'obtention du diplôme de maîtrise spécialisée en GRENE, Université de Toamasina, Madagascar. pp. 16–22.
von Koenen, E., 2001. Medicinal, poisonous and edible plants in Namibia. Klaus Hess Verlag, Göttingen, Germany. 336 pp.
von Maydell, H.-J., 1983. Arbres et arbustes du Sahel: leurs caractéristiques et leurs utilisations. Schriftenreihe der GTZ 147. Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ) GmbH, Eschborn, Germany. 531 pp.
von Maydell, H.-J., 1986. Trees and shrubs of the Sahel: their characteristics and uses. Schriftenreihe der GTZ No 196. Deutsche Gesellschaft für Technische Zusammenarbeit, Eschborn, Germany. 525 pp.
Voorhoeve, A.G., 1979. Liberian high forest trees. A systematic botanical study of the 75 most important or frequent high forest trees, with reference to numerous related species. Agricultural

Research Reports 652, 2nd Impression. Centre for Agricultural Publishing and Documentation, Wageningen, Netherlands. 416 pp.

Vymazal, J., 2011. Plants used in constructed wetlands with horizontal subsurface flow: a review. Hydrobiologia 672.

Waage, S.K. & Hedin, P.A., 1984. Biologically-active flavonoids from Gossypium arboreum. Phytochemistry 23(11): 2509–2511.

Wagner, T., 2004. Le lio, un produit de terroir: analyse des systèmes de production du lio à Abomey et Bohicon. Working Papers No 50. Institut für Ethnologie und Afrikastudien, Johannes Gutenberg-Universität, Mainz, Germany. 51 pp.

Waliszewski, W.S., Oppong, S., Hall, J.N. & Sinclair, F.L., 2005. Implications of local knowledge of the ecology of a wild super sweetener for its domestication and commercialization in West and Central Africa. Economic Botany 59(3): 231–243.

Walker, A., 1931. L'emoumou (Podococcus barteri): palmier intéressant du Gabon. Revue de Botanique Appliquée & d'Agriculture Tropicale 11: 933–934.

Walker, A., 1950. Etude sur quelques plantes aquatiques du Gabon. Revue Internationale de Botanique Appliquée et d'Agriculture Tropicale 50(327/328): 439–440.

Wallace, T.P., Bowman, D., Campbell, B.T., Chee, P., Gutierrez, O.A., Kohel, R.J., McCarty, J., Myers, G., Percy, R., Robinson, F., Smith, W., Stelly, D.M., Stewart, J.W., Thaxton, P., Ulloa, M. & Weaver, D.B., 2009. Status of the USA cotton germplasm collection and crop vulnerability. Genetic Resources and Crop Evolution 56(4): 507–532.

Walters, C., Wheeler, L.M. & Grotenhuis, J.M., 2005. Longevity of seeds stored in a genebank: species characteristics. Seed Science Research 15: 1–20.

Wang, B. & Qiu, Y.L., 2006. Phylogenetic distribution and evolution of mycorrhizas in land plants. Mycorrhiza 16: 299–363.

Wang, Q., Cui, Y. & Dong, Y., 2002. Phytoremediation of polluted waters: potentials and prospects of wetland plants. Acta Biotechnologica 22(1–2): 199–208.

Wang, B., Peng, D.-X., Sun Z.-X., Zhang, N. & Xing, X.-L., 2007. Regeneration of transgenic ramie plants expressing green fluorescent protein mediated by Agrobacterium tumefaciens. Acta Agronomica Sinica 33(10): 1606–1610.

Wang, J.Q., Ferrell, J., MacDonald, G. & Sellers, B., 2009. Factors affecting seed germination of Cadillo (Urena lobata). Weed Science 57(1): 31–35.

Wanke, S., González, F. & Neinhuis, C., 2006. Systematics of pipevines: combining morphological and fast-evolving molecular characters to investigate the relationships within subfamily Aristolochioideae (Aristolochiacea). International Journal of Plant Sciences 167(6): 1215–1227.

Warrand, J., Michaud, P., Picton, L., Muller, G., Courtois, B., Ralainirina, R. & Courtois, J., 2005a. Flax (Linum usitatissimum) Seed Cake: A potential source of high molecular weight arabinoxylans? Journal of Agricultural and Food Chemistry 53: 1449–1452.

Warrand, J., Michaud, P., Picton, L., Muller, G., Courtois, B., Ralainirina, R. & Courtois, J., 2005b. Structural investigations of the neutral polysaccharide of Linum usitatissimum L. seeds mucilage. International Journal of Biological Macromolecules 35: 121–125.

Watson, L. & Dallwitz, M.J., 1992. Grass genera of the world. CAB International, Wallingford. 1038 pp.

Watson, L. & Dallwitz, M.J., 1992–. The families of flowering plants: descriptions, illustrations, identification, and information retrieval. [Internet]. <http://delta-intkey.com>. Accessed September 2009.

Watt, J.M. & Breyer-Brandwijk, M.G., 1962. The medicinal and poisonous plants of southern and eastern Africa. 2nd Edition. E. and S. Livingstone, London, United Kingdom. 1457 pp.

Webb, D.B., Wood, P.J., Smith, J.P. & Henman, G.S., 1984. A guide to species selection for tropical and sub-tropical plantations. 2nd Edition. Tropical Forestry Papers No 15. Commonwealth Forestry Institute, University of Oxford, United Kingdom. 256 pp.

Weber, N.A., 1942. A biocoenose of papyrus heads (Cyperus papyrus). Ecology 23(1): 115–119.

Wehmeyer, A.S., 1986. Edible wild plants of southern Africa. Data on the nutrient contents of over 300 species. Scientia, Pretoria, South Africa. 52 pp.

Wei, L.S., Musa, N., Sengm, C.T., Wee, W. & Mohd Shazili, N.A., 2008. Antimicrobial properties of tropical plants against 12 pathogenic bacteria isolated from aquatic organisms. African Journal of Biotechnology 7(13): 2275–2278.

Weiss, E.A., 1973. Some indigenous trees and shrubs used by local fishermen on the East African coast. Economic Botany 27(2): 175–192.

Weiss, E.A., 1979. Some indigenous plants used domestically by East African coastal fishermen. Economic Botany 33(1): 35–51.

Wells, M.J., Balsinhas, V.M., Joffe, H., Engelbrecht, V.M., Harding, G. & Stirton, C.H., 1986. A catalogue of problem plants in Southern Africa, incorporating the National Weed List of South Africa. Memoirs of the Botanical Survey of South Africa No. 53. Botanical Research Institute, Pretoria, South Africa. 663 pp.

Weniger, B., Lagnika, L., Vonthron-Sénécheau, C., Adjobimey, T., Gbenou, J., Moudachirou, M., Brun, R., Anton, R. & Sanni, A., 2004. Evaluation of ethnobotanically selected Benin medicinal plants for their in vitro antiplasmodial activity. Journal of Ethnopharmacology 90: 279–284.

Westphal, E., 1975. Agricultural systems in Ethiopia. Agricultural Research Reports 826. Centre for Agricultural Publishing and Documentation, Wageningen, Netherlands. 278 pp.

Westphal, E., 1981. L'agriculture autochtone au Cameroun: les techniques culturales, les séquences de culture, les plantes alimentaires et leur consommation. Miscellaneous papers No 20. Landbouwhogeschool Wageningen, Netherlands. 175 pp.

Westphal, E., Embrechts, J., Ferwerda, J.D., van Gils-Meeus, H.A.E., Mutsaers, H.J.W. & Westphal-Stevels, J.M.C., 1985. Cultures vivrières tropicales avec référence spéciale au Cameroun. Pudoc, Wageningen, Netherlands. 514 pp.

Whistler, W.A. & Elevitch, C.R., 2006. Broussonetia papyrifera (paper mulberry), version 2.1. In: Elevitch, C.R. (Editor). Species Profiles for Pacific Island Agroforestry. Permanent Agriculture Resources (PAR), Holualoa, Hawaii. 13 pp.

White, F., 1963a. Ebenaceae. In: Hepper, F.N. (Editor). Flora of West Tropical Africa. Volume 2. 2nd Edition. Crown Agents for Oversea Governments and Administrations, London, United Kingdom. pp. 2–15.

White, F., 1963b. Notes on the Ebenaceae. 5. Some new names and new species in Diospyros. Bulletin du Jardin Botanique de Bruxelles 33: 345–367.

White, F., 1978. The taxonomy, ecology and chorology of African Ebenaceae I. The Guineo Congolian species. Bulletin du Jardin Botanique National de Belgique 48: 245–358.

White, F., 1983. Ebenaceae. In: Launert, E. (Editor). Flora Zambesiaca. Volume 7, part 1. Flora Zambesiaca Managing Committee, London, United Kingdom. pp. 248–300.

White, F., 1987. Ebenaceae. In: Bamps, P. (Editor). Flore d'Afrique centrale. Spermatophytes. Jardin botanique national de Belgique, Brussels, Belgium. 103 pp.

White, L. & Abernethy, K., 1997. A guide to the vegetation of the Lopé Reserve, Gabon. 2nd edition. Wildlife Conservation Society, New York, United States. 224 pp.

White, G.A. & Haun, J.R., 1965. Growing Crotalaria juncea, a multi-purpose legume, for paper pulp. Economic Botany 19: 175–183.

White, L.J.T., Rogers, M.E., Tutin, C.E.G., Williamson, E.A. & Fernandez, M., 1995. Herbaceous vegetation in different forest types in the Lopé Reserve, Gabon: implications for keystone food availability. African Journal of Ecology 33(2): 124–141.

Whitehouse, C., 2002. Asphodelaceae. In: Beentje, H.J. & Ghazanfar, S.A. (Editors). Flora of Tropical East Africa. A.A. Balkema, Rotterdam, Netherlands. 20 pp.

Whitehouse, C., Cheek, M., Andrews, S. & Verdcourt, B., 2001. Tiliaceae & Muntingiaceae. In: Beentje, H.J. (Editor). Flora of Tropical East Africa. A.A. Balkema, Rotterdam, Netherlands. 120 pp.

Whyte, R.O., 1974. Tropical grazing lands; communities and constituent species. Junk, The Hague, Netherlands. 222 pp.

Wickens, G.E., 1973. Combretaceae. In: Polhill, R.M. (Editor). Flora of Tropical East Africa. Crown Agents for Oversea Governments and Administrations, London, United Kingdom. 99 pp.

Wickens, G.E., 1980. Alternative uses of browse species. In: Le Houérou, H.N. (Editor). Browse in Africa: the current state of knowledge. International Livestock Centre for Africa, Addis Ababa, Ethiopia. pp. 155–182.

Wieckhorst, A., 2002. Die Verwendung von Pflanzen in der traditionellen Medizin bei drei Baka Gruppen in südost Kamerun. Kölner Ethnologische Beiträge, Heft 2. Institut für Völkerkunde, Universität zu Köln, Germany. 153 pp.

Wiemann, M.C. & Williamson, G.B., 1989. Wood specific gravity gradients in tropical dry and montane rain forest trees. American Journal of Botany 76(6): 924–928.

Wienk, J.F., 1995. Sisal and relatives. In: Smartt, J. & Simmonds, N.W. (Editors): Evolution of crop plants. 2nd Edition. Longman, Harlow, United Kingdom. pp. 4–8.

Wijnands, D.O., 1973. Typification and nomenclature of two species of Sansevieria (Agavaceae). Taxon 22(1): 109–114.

Wilczek, R., 1960a. Celastraceae. In: Robyns, W., Staner, P., Demaret, F., Germain, R., Gilbert, G., Hauman, L., Homès, M., Jurion, F., Lebrun, J., Vanden Abeele, M. & Boutique, R. (Editors). Flore du Congo belge et du Ruanda-Urundi. Spermatophytes. Volume 9. Institut National pour l'Étude Agronomique du Congo belge, Brussels, Belgium. pp. 113–132.

Wilczek, R., 1960b. Hippocrateaceae. In: Robyns, W., Staner, P., Demaret, F., Germain, R., Gilbert, G., Hauman, L., Homès, M., Jurion, F., Lebrun, J., Vanden Abeele, M. & Boutique, R. (Editors). Flore du Congo belge et du Ruanda-Urundi. Spermatophytes. Volume 9. Institut National pour l'Étude Agronomique du Congo belge, Brussels, Belgium. pp. 133–232.

Wilczek, R., 1963. Tiliaceae. In: Robyns, W., Staner, P., Demaret, F., Germain, R., Gilbert, G., Hauman, L., Homès, M., Jurion, F., Lebrun, J., Vanden Abeele, M. & Boutique, R. (Editors). Flore du Congo belge et du Ruanda-Urundi. Spermatophytes. Volume 10. Institut National pour l'Étude Agronomique du Congo belge, Brussels, Belgium. pp. 1–91.

Wilczek, R., Léonard, J., Hauman, L., Hoyle, A.C., Steyaert, R., Gilbert, G. & Boutique, R., 1952. Caesalpiniaceae. In: Robyns, W., Staner, P., Demaret, F., Germain, R., Gilbert, G., Hauman, L., Homès, M., Jurion, F., Lebrun, J., Vanden Abeele, M. & Boutique, R. (Editors). Flore du Congo belge et du Ruanda-Urundi. Spermatophytes. Volume 3. Institut National pour l'Étude Agronomique du Congo belge, Brussels, Belgium. pp. 234–554.

Wild, H., 1962. Harmful aquatic plants in Africa and Madagascar. Kirkia 2: 1–67.

Wild, H., 1963. Tiliaceae. In: Exell, A.W., Fernandes, A. & Wild, H. (Editors). Flora Zambesiaca. Volume 2, part 1. Crown Agents for Oversea Governments and Administrations, London, United Kingdom. pp. 33–91.

Wild, H., 1984. Tiliaceae. In: Leistner, O.A. (Editor). Flora of southern Africa. Volume 21, part 1. Botanical Research Institute, Department of Agriculture, Pretoria, South Africa. 44 pp.

Wild, H. & Gonçalves, M.L., 1969. Tiliaceae. In: Fernandes, A. (Editor). Flora de Moçambique. No 28. Junta de Investigações do Ultramar, Lisbon, Portugal. 69 pp.

Wild, R.G. & Mutebi, J., 1996. Conservation through community use of plant resources: establishing collaborative management at Bwindi Impenetrable and Mgahinga Gorilla National Parks, Uganda. People and Plants Working Paper No 5. UNESCO, Paris, France. 45 pp.

Williams, J.E. & Woinarski, J. (Editors), 1997. Eucalypt ecology: individuals to ecosystems. Cambridge University Press, Cambridge, United Kingdom. 430 pp.

Williamson, J., 1955. Useful plants of Nyasaland. The Government Printer, Zomba, Nyasaland. 168 pp.

Wilman, V., 2003. Bolboschoenus maritimus. [Internet] South African National Biodiversity Institute, Cape Town, South Africa. <http://www.plantzafrica.com/ plantab/ bolbomari.htm>. Accessed June 2011.

Wilmot-Dear, C.M. & Friis, I., 2006. The Old World species of Pouzolzia (Urticaceae, tribus Boehmerieae). A taxonomic revision. Nordic Journal of Botany 24(1): 5–111.

Wilson, F.D., 1967. An evaluation of kenaf, roselle and related Hibiscus for fiber production. Economic Botany 21(2): 132–139.

Wilson, F.D., 1978. Wild kenaf, Hibiscus cannabinus L. (Malvaceae), and related species in Kenya and Tanzania. Economic Botany 32(2): 199–204.

Wilson, F.D., 1999. Revision of Hibiscus section Furcaria (Malvaceae) in Africa and Asia. Bulletin of the Natural History Museum, Botany Series 29: 47–79.

Wilson, J.R. & Kennedy, P.M., 1986. Plant and animal constraints to voluntary feed intake associated with fiber characteristics and particle breakdown and passage in ruminants. Australian Journal of Agricultural Research 47(2): 199–225.

Wilson, F.D. & Menzel, M.Y., 1964. Kenaf (Hibiscus cannabinus L.), roselle (Hibiscus sabdariffa L.). Economic Botany 18: 80–91.

Wilson, F.D., Joyner, J.F. & Fishler, D.W., 1969. Fiber yields in Sansevieria interspecific hybrids. Economic Botany 23(1): 148–155.

Wise, R.R., Sassenrath-Cole, G.F. & Percy, R.G., 2000. A comparison of leaf anatomy in field grown Gossypium hirsutum and Gossypium barbadense. Annals of Botany 86: 731–738.

Wiselius, S.I., 1998. Hibiscus L. In: Sosef, M.S.M., Hong, L.T. & Prawirohatmodjo, S. (Editors). Plant Resources of South-East Asia No 5(3). Timber trees: Lesser-known timbers. Backhuys Publishers, Leiden, Netherlands. pp. 289–292.

Wolfson, D., Marani, A. & Steinitz, B., 1987. Chilling sensitivity of roselle. HortScience 22: 954.

Wome, B., 1985. Recherches ethnopharmacognosiques sur les plantes médicinales utilisées en médecine traditionnelle à Kisangani (Haut-Zaïre). PhD thesis, Faculty of Sciences, University of Brussels, Brussels, Belgium. 561 pp.

Wondimu, T., Asfaw, Z. & Kelbessa, E., 2007. Ethnobotanical study of medicinal plants around 'Dheeraa' town, Arsi Zone, Ethiopia. Journal of Ethnopharmacology 112: 152–161.

Wong, C., Kiew, R., Argent, G., Ohn, S., Lee, S.K. & Gan, Y.Y., 2002. Assessment of the validity of the sections in Musa (Musaceae) using AFLP. Annals of Botany 90(2): 231–238.

Wood, I.M., 1997. Fibre Crops: new opportunities for Australian Agriculture. Queensland Department of Primary Industries, Brisbane, Australia. pp. 73–78.

Woode, E., Poku, R.A., Ainooson, G.K., Boakye-Gyasi, E., Abotsi, W.K.M., Mensah, T.L. & Amoh Barimah, A.K., 2009. An evaluation of the anti-inflammatory, antipyretic and antinociceptive effects of Ficus exasperata (Vahl) leaf extract. Journal of Pharmacology and Toxicology 4(4): 138 151.

World Agroforestry Centre, undated. Agroforestree Database. [Internet] World Agroforestry Centre (ICRAF), Nairobi, Kenya. <http://www.worldagroforestry.org/ resources/databases/ agroforestree>. Accessed September 2007 - September 2009.

World Conservation Monitoring Centre, 1998. Casearia barteri. In: IUCN. Red list of threatened species. Version 2010.1. [Internet] <http://www.iucnredlist.org>. Accessed March 2010.

Wright, C.H., 1901–1902. Palmae. In: Thiselton-Dyer, W.T. (Editor). Flora of tropical Africa. Volume 8. Lovell Reeve & Co, London, United Kingdom. pp. 97–127.

Wright, C.I., Van-Buren, L., Kroner, C.I. & Koning, M.M.G., 2007. Herbal medicines as diuretics: a review of the scientific evidence. Journal of Ethnopharmacology 114: 1–31.

Wu, D. & Kress, W.J., 2000. Musaceae. [Internet] Flora of China 24: 297–313. <http://www.efloras.org/ florataxon.aspx?flora_id=2&taxon_id=10588>. Accessed September 2010.

Wu, Z., Zhou, Z.-K. & Gilbert, M.G., 2004. Moraceae. [Internet] Flora of China 5: 21–37. <http://www.efloras.org/ florataxon.aspx?flora_id=2&taxon_id=10588>. Accessed March 2011.

Xiongfeng Ma, Chunming Yu, Shouwei Tang, Sandui Guo, Rui Zhang, Yanzhou Wang, Aiguo Zhu, Siyuan Zhu and Heping Xiong, 2010. Genetic transformation of the bast fiber plant ramie (Boehmeria nivea Gaud.) via Agrobacterium tumefaciens. Plant Cell, Tissue and Organ Culture 100(2): 165–174.

Xiuhong, J., Khan, I., Mosjidis, J.A., Hui Wang & Livant, P., 2005. Variability for the presence of pyrrolizidine alkaloids in Crotolaria juncea L. Pharmazie 60: 620–622.

Yamada, T., 1984. Nyindu culture and the plant world: the dynamic relationship between the knowledge on plant use and the change in house form. Senri Ethnological Studies No 15. 107 pp. [Internet] <http://ir.minpaku.ac.jp/ dspace/bitstream/10502/431/1/ SES15_003.pdf>. Accessed February 2010.

Yamada, T., 1999. A report of the ethnobotany of the Nyindu in the eastern part of the former Zaire. African Study Monographs 20(1): 1–72.

Yamagiwa, J., Mwanza, N., Yumoto, T. & Maruhashi, T., 1994. Seasonal change in the composition of the diet of eastern lowland gorillas. Primates 35: 1–14.

Yandoc, C.B., Charudattan, R. & Shilling, D.G., 2005. Evaluation of fungal pathogens as biological control agents for cogongrass (Imperata cylindrical). Weed Technology 19: 19–26.

Yélémou, B., Yaméogo, G., Millogo Rasolodimby, J. & Hien, V., 2007a. Germination sexuée et dynamique de développement de Piliostigma reticulatum (D.C.) Hochst, une espèce agroforestière du Burkina Faso. Sécheresse, vol. 18(3): 185–192.

Yélémou, B., Bationo, B.A., Yaméogo, G. & Millogo-Rasolodimby, J., 2007b. Gestion traditionnelle et usages de Piliostigma reticulatum sur le Plateau central du Burkina Faso. Bois et Forêts des Tropiques 291(1): 55–66.

Yembi, P., 1999. A preliminary survey of the non-wood forest products of the Libreville markets (Gabon). In: Sunderland, T.C.H., Clark, L.E. & Vantomme, P. (Editors). Non-wood forest products of Central Africa: current research issues and prospects for conservation and development. FAO, Rome, Italy. pp. 233–236.

Yokosuka, A., Sano, T., Hashimoto, K., Sakagami, H. & Mimaki, Y., 2009. Steroidal glycosides from Furcraea foetida and their cytotoxic activity. Chemical and Pharmaceutical Bulletin 57(10): 1161–1166.

Yoon, J.S., Lee, M.K., Sung, S.H. & Kim, Y.C., 2006. Neuroprotective 2-(2-phenylethyl)chromones of Imperata cylindrica. Journal of Natural Products 69(2): 290–291.

Youmbie, D.D.B., 2008. Effets analgésiques et anti-inflammatoires de l'extrait aqueux de Piliostigma reticulatum (D.C) Hochst (Caesalpiniaceae) chez les souris et les rats albinos. Mémoire de DEA, Département de Biologie Animale, Faculté des Sciences, Université de Yaoundé I, Yaoundé, Cameroun. 54 pp.

Zakaria, Z.A., Mat Desa, A., Ramasamy, K., Ahmat, N., Mohamad, A.S., Israf, D.A. & Sulaiman, M.R., 2010. Lack of antimicrobial activities of Dicranopteris linearis extracts and fractions. African Journal of Microbiology Research 4(1): 71–75.

Zanna, H., Adeniji, S., Shehu, B.B., Modu, S. & Ishaq, G.M., 2008. Effects of aqueous suspension of the root of Hyphaene thebaica (L.) Mart on some indicators of liver and kidney function in rats. Journal of Pharmacology and Toxicology 3(4): 330–334.

Zapfack, L., Ayeni, J.S.O., Besong, S. & Mdaihli, M., 2001. Ethnobotanical survey of the Takamanda Forest Reserve. Consultancy report submitted to PROFA (MINEF-GTZ), Mamfe, Cameroon. 90 pp.

Zaré, A., 1991. Synthèses partielles des essais de conservation de semences de quelques espèces. Rapport de stage 3è année, Institut du Développement Rural (IDR), Université de Ouagadougou, Ouagadougou, Burkina Faso. 63 pp.

Zavada, M.S. & Lowrey, T.K., 1995. Floral heteromorphism in Dais cotinifolia l. (Thymelaeaceae): a possible case of heterostyly. Bulletin du Muséum National d'Histoire Naturelle, 4e série, 17, section B, Adansonia 1–2: 11–20.

Zech, W. & Drechsel, P., 1992. Multiple mineral deficiencies in forest plantations in Liberia. Forest Ecology and Management 48(1–2): 121–143.

Zehran, M.A., 1979. The halophytes and their economic potentialities. Proceedings of the Saudi Biological Society 3: 133–137.

Zeven, A.C. & Zhukovsky, P.M., 1975. Dictionary of cultivated plants and their centres of diversity. Pudoc, Wageningen, Netherlands. 219 pp.

Zheng, Z.P., Cheng, K.W., Chao, J., Wu, J. & Wang, M., 2008. Tyrosinase inhibitors from paper mulberry (Broussonetia papyrifera). Food Chemistry 106: 529–535.

Zietsman, P.C., 1994. Autogamy in Sesamum triphyllum var. triphyllum (Pedaliaceae). Navorsinge van die Nasionale Museum (Bloemfontein) 10(15): 633–646.

Zimmermann, M.H., Tomlinson, P.B. & LeClaire, J., 1974. Vascular construction and development in the stems of certain Pandanaceae. Botanical Journal of the Linnean Society 68(1): 21–41.

Zohary, D. & Hopf, M., 2000. Domestication of plants in the Old World: the origin and spread of cultivated plants in West Asia, Europe and the Nile Valley. 3rd Edition. Oxford University Press, Oxford, United Kingdom. 316 pp.

Zoro Bi, I.A. & Kouakou, K.L., 2004. Vegetative propagation methods adapted to two rattan species Laccosperma laeve and Laccosperma secundiflorum. Tropicultura 22(4): 163–167.

Zwane, P.E., Masarirambi, M.T., Seyoum, T. & Nkosi, B.S., 2011. Natural fibre plant resources of economic value found in wetlands of Swaziland: a review. African Journal of Agricultural Research 6(4): 774–779.

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PROTA

Plant Resources of Tropical Africa

Ressources végétales de l'Afrique tropicale

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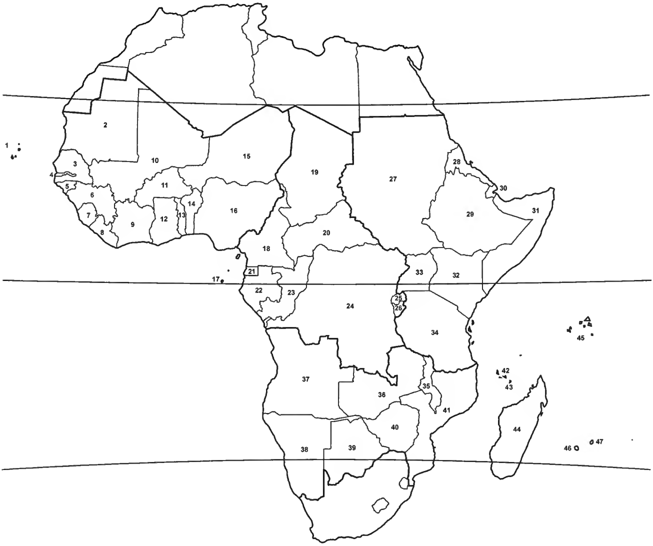

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PROTA 16 deals with the fibres of Tropical Africa. PROTA's database 'SPECIESLIST' presents 1420 species used as such. 515 among them are 'primary use' fibres qualifying for treatment in this volume, the other 905 species have been listed as 'Fibres with other primary use' and referred to other Handbook volumes. The 515 'primary use' fibres are described in 248 review articles, implying that 267 species are briefly mentioned and described in the articles of more important related species; they have no separate article due to lack of information.

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